Report Rapport

Atomic Energy
Control Board

Commission de contrôle
de l'énergie atomique

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VERIFICATION OF THE PERFORMANCE OF IMPACT LIMITING FINS FOR TRANSPORTATION CONTAINERS

by

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Research report

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ABSTRACT

Empirical data are frequently applied in designing the crush limiting fins for the special transport containers used for shipping radioactive materials. One of the most widely accepted sets of design curves was derived from research work done at Oak Ridge National Laboratories (ORNL) in 1971.

This report presents the results of experimental work aimed at verifying particular aspects of the applicability of the ORNL design curves. The main objective was to check the fundamental assumption inherent in the ORNL data - namely that the design curve data can be extrapolated to any fin configuration regardless of the length and number of fins.

Using a drop facility similar to ORNL, but with a modern computerized data capture system, data were collected from 625 specimens. These comprised both single and multiple fin types, that differed in height, thickness, length, angle of inclination and orientation. Included were several duplicate ORNL fin specimens for reference.

Results obtained from the work reported here indicate that the basic premise regarding the extrapolation form the design curve data is reasonable. However, the results do not produce curves consistent with the ORNL curves. The newer curves of absorbed energy versus percent deformation are flatter, indicating that the percent deformation for a given energy input can sometimes vary considerably. For plots of the peak force per fin width versus height/thickness ratios the sharp upward trend for height/thickness ratios below 10 is not observed.

The results obtained indicate that further work should be performed to determine the reason for the differences between the ORNL data and those data obtained from this project.

DISCLAIMER

The opinions expressed in this report are those of the authors and do not necessarily reflect those of the Atomic Energy Control Board.

RÉSUMÉ

On applique souvent des données empiriques pour concevoir les ailettes anti-choc des conteneurs de transport spéciaux utilisés pour l'expédition des matières radioactives. Un des différents groupes de courbes de conception les plus acceptés découle du travail de recherche mené aux Oak Ridge National Laboratories (ORNL) en 1971.

Le présent rapport fournit les résultats du travail expérimental qui visait à vérifier les aspects particuliers de l'applicabilité des courbes de conception des ORNL. Le but principal était de vérifier l'hypothèse inhérente fondamentale des données des ORNL, notamment en ce qui a trait aux données des courbes de conception qu'on pourrait extrapoler pour chacune des configurations d'ailettes, nonobstant la longeur et le nombre d'ailettes.

Grâce à une installation de chute semblable aux ORNL, jumelée cependant à un système informatique moderne de saisie de données, on a réussi à obtenir des données pour 625 spécimens. Parmi ceux-ci, on comptait autant des modèles à ailettes simples que multiples qui différaient également en hauteur, en épaisseur, en longueur, en angle d'inclinaison et en orientation. Il y avait aussi plusieurs doubles des spécimens d'ailettes des ORNL à titre de référence.

À partir des résultats obtenus, on a pu indiquer que la prémisse de base au sujet de l'extrapolation possible à partir des données des courbes de conception était raisonnable. Toutefois, on n'a pas réussi à obtenir des courbes qui soient cohérentes avec celles des ORNL. Les courbes plus récentes d'énergie absorbée par rapport au pourcentage de déformation sont plus planes, indiquant par là que le pourcentage de déformation pour les données d'une énergie donnée peuvent varier considérablement. Dans le cas des tracés de la force de pointe par ailette par rapport aux proportions de la hauteur et de l'épaisseur, on n'a pas observé de forte tendance ascendante pour les proportions de la hauteur et de l'épaisseur inférieures à 10.

Les résultats obtenus indiquent qu'il faudrait procéder à des travaux supplémentaires pour expliquer la différence entre les données des ORNL et celles qui font l'objet du présent projet.

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1.0 INTRODUCTION

The special containers used for transporting radioactive materials must, for obvious safety reasons, be built to remain intact if they are dropped or involved in some sort of collision. To ensure that these transportation containers are adequately designed, regulations require that they be designed to survive certain prescribed hypothetical accident conditions. The commonly adopted approach is to build an energy absorbing capability into the design. In many of the larger and heavier containers, the impact energy is absorbed through the gross plastic deformation of external metal fins that are either welded onto the outer surface of the cask, or are attached to the ends of the container in removable fin-like fixtures during transportation.

While the concept is straight-forward, the structural analysis of actual crush fin configurations undergoing gross plastic deformation is not, and consequently much of the design of crush fins for transportation containers is based upon empirical design curves derived from experimental drop test data. One of the most widely used sets of design curves comes from impact experiments done in 1971 by Davis (1) of Oak Ridge National Laboratories (ORNL). His investigation measured the impact performance of single fins 2 inches (50.8 mm) wide varying in length from 3.5 to 10 inches (88.9 to 254 mm), in thickness from 1/4 to 3/4 inches (6.4 to 19.1 mm) and angle of inclination to the impact direction from 0 to 40 degrees. He tested 275 specimens in total. The purpose of Davis's investigation was to determine the energy absorption characteristics of external fins along the longitudinal axis of a cylindrical container subjected to the hypothetical 30 foot (9 m) free fall design condition. The design curves that he derived were intended to permit the cask designer or analyst to compute the energy absorption capacity of a longitudinal find as a function of its geometry and the percentage of deformation it is permitted to experience during impact.

This report contains results of drop tests that were aimed at verifying and extending the ORNL data. The work was performed for the Atomic Energy Control Board of Canada by Monserco Limited, Mississauga, Ontario under a contract issued by Department of Supply and Services, Ottawa (DSS File No. 02SQ.87055-3-4014).

1.1 Note on the System of Units Adopted in this Report

In this project, we have departed from the normal practice of using the SI system of units and have deliberately adopted Imperial units throughout the report to facilitate the comparison of our results with the ORNL data.

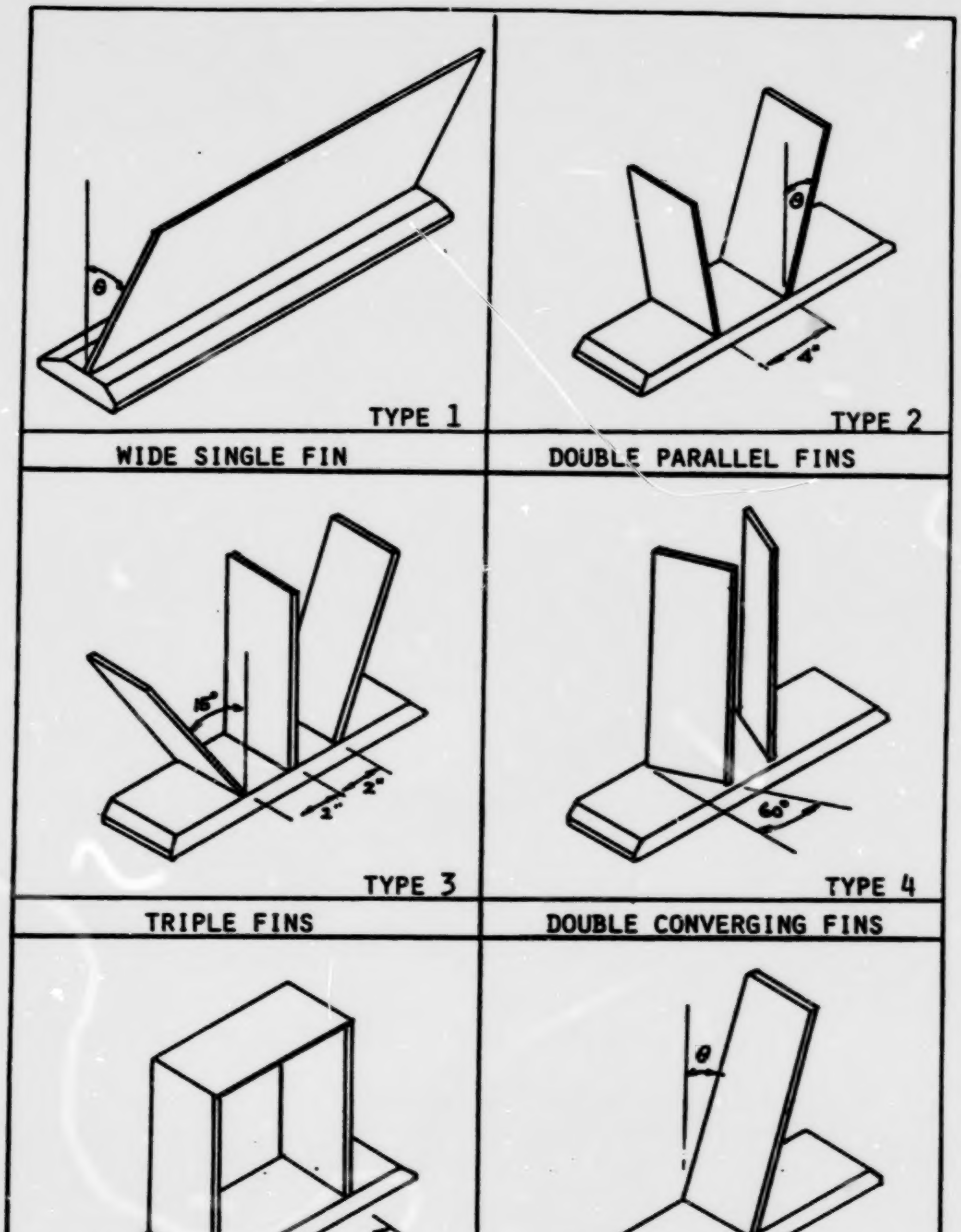
2.0 DESCRIPTION OF WORK PERFORMED

2.1 Objectives

The main objective of this study was to test the validity of a fundamental assumption in the ORNL data. This assumption is that the energy absorption and peak force data obtained from the single fins as tested at ORNL, can be factored in proportion to the width and number of fins for actual application. To this end, various configurations of fin test specimens were fabricated, as illustrated in Figures 1 and 2. These specimens could be separated into two basic groups:

i) the first group comprised single fins similar to the ORNL configurations except that they were five times wider (10 inches [254 mm] as opposed to 2 inches [50.8 mm] at ORNL). These specimens were for examining whether the data could be factored in proportion to fin width.

ii) the second group comprised multiple fin specimens, all 2 inches [50.8 mm] wide, welded either in vertical parallel pairs, in vertical non-parallel pairs or in a three-fin arrangement, where the central fin was vertical and the other two were inclined at 15 degrees to the vertical either side of the central fin. These specimens were for examining the assumption of factoring



TYPE 1

WIDE SINGLE FIN

TYPE 2

DOUBLE PARALLEL FINS

TYPE 3

TRIPLE FINS

TYPE 4

DOUBLE CONVERGING FINS

TYPE 5

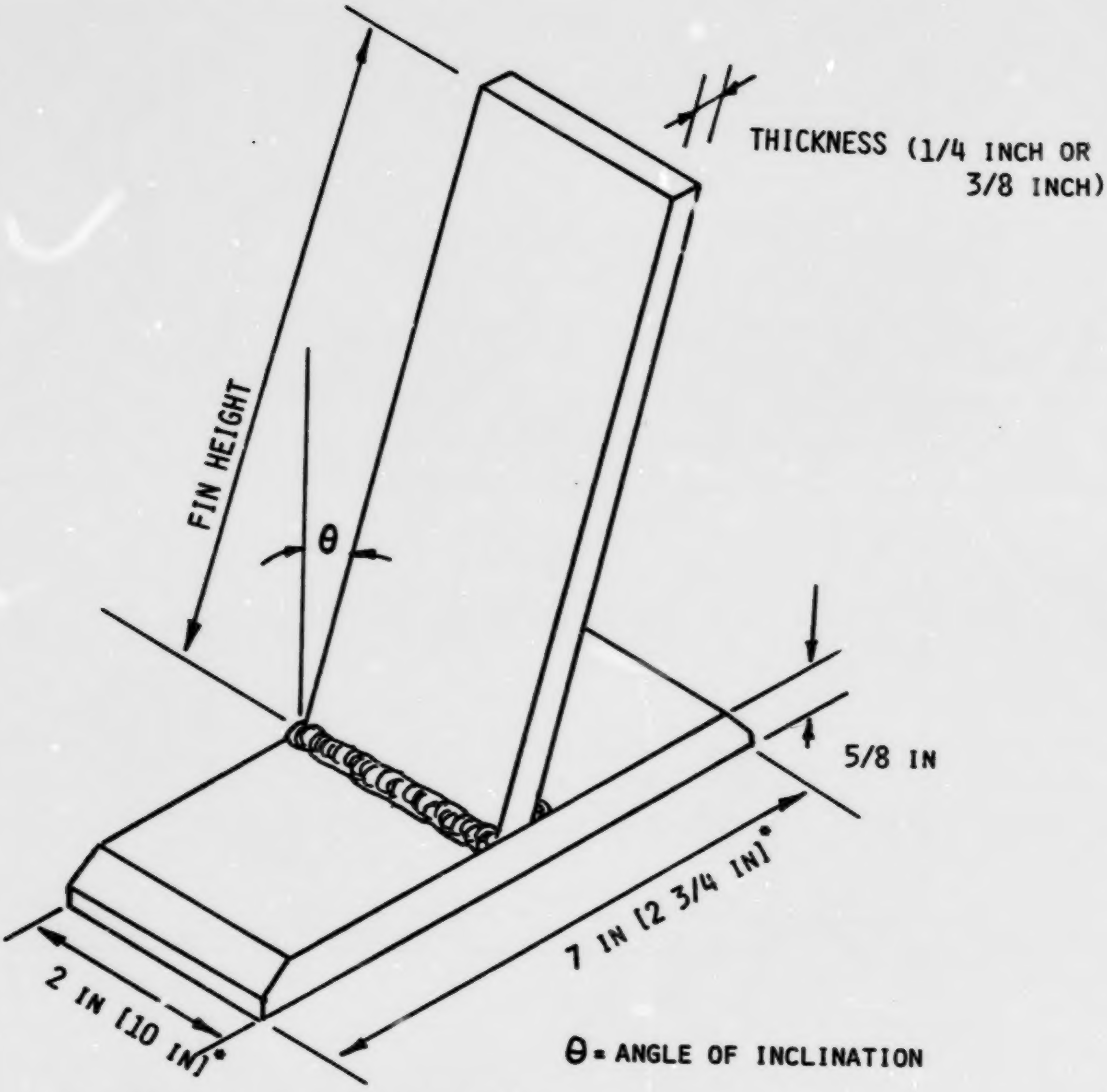
DOUBLE BRACED FINS

TYPE 6

OAK RIDGE FIN

FIGURE 1

CONFIGURATION OF FINS TESTED


THICKNESS (1/4 INCH OR 3/8 INCH)
FIN HEIGHT
θ
5/8 IN
7 IN [2 3/4 IN]*
2 IN [10 IN]*
θ = ANGLE OF INCLINATION

* DIMENSIONS SHOWN IN [ ] APPLY
TO THE 10 INCH WIDE FIN SPECIMENS

FIGURE 2

FIN AND BASE DIMENSIONS OF SPECIMENS TESTED by fin number, and also to see if different parallel fin configurations produce significantly different results.

A second objective was to determine whether the ORNL test results could be repeated by doing similar drop tests on fins the same size as the ORNL specimens. This was to be done on only a selection of replica ORNL fin configurations - ie vertical and 30 degree inclined. Good agreement between the ORNL and the Monserco fin results would confirm the validity of the design curves and provide a degree of confidence in the data for design purposes.

A third objective was to examine the final shapes of the deformed fins to see if it was possible to establish rules that might predict failure modes of the various fin configurations.

The nature of this work was therefore primarily corraborative, with the emphasis being on verifying and extending current knowledge on fin design to aid regulatory staff in their reviewing of container designs. It was not intended to be a piece of original research aimed at generating comprehensive design data curves.

2.2 Test Procedure

The same basic test procedure adopted at ORNL was followed for the work reported here. Briefly, ORNL's general approach involved dropping a hammer of known weight from a predetermined height onto a fin specimen clamped on top of a load cell fixture. The force-time relationship experienced by the specimen throughout the resulting impact was obtained by simultaneously recording the oscilloscope traces from the load cell and an accelerometer mounted on the hammer. Multiple numerical integrations were performed on the captured transient data to obtain the deformation-time and the absorbed energy-time relationships during impact. These were then used to derive curves of absorbed energy versus deformation. The results from 275 fins were summarized in a series of curves for each of the four different angles of fin inclination.

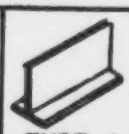
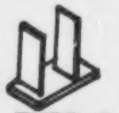
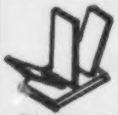
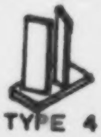
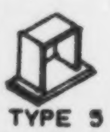
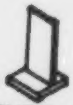
A similar drop test facility comprising base, tower, hoist, hammer and load cell arrangement was constructed, the details of which are described in Appendix A. However, with the advancement of electronic technology since 1971 it is possible to improve the method of data capture significantly. By using a digitizing oscilloscope coupled to a VAX minicomputer, the load cell and accelerometer traces could be captured and stored in digital form with high resolution. This was a great improvement over the ORNL method of a Polaroid camera attachment on the oscilloscope, and it made processing of the test data much more efficient. Details of the Monserco instrumentation arrangement can also be found in the description of the test facility in Appendix A.

2.3 Test Specimens

A total of 625 fin test specimens were fabricated for this study. Fins were of two thicknesses, 1/4 inch (6.4 mm) and 3/8 inch (9.5 mm), and of five different lenghts between 3 1/2 and 10 inches (88.9 and 254 mm). The single fins had four different angles of inclination: 0, 10, 20 and 30 degrees from the vertical. To lend some statistical significance to the results, five specimens of each configuration were fabricated. Table 1 summarizes the various combinations of fin dimensions for each test specimen arrangement.

All specimens were fabricated from the same material that ORNL used - namely ASTM A 285, Grade C. However, the value for the yield strength for this material differed from that quoted in the ORNL report. The yield strength obtained from batch samples of the Monserco test material was 39860 psi (275 MPa) for the 1/4 inch (6.4 mm) plate, and 41380 psi (285 MPa) for the 3/8 inch (9.5 mm) plate. The 30000 psi (207 MPa) figure used in producing the ORNL curves, appears to be a minimum specification value, rather than an actual measured value.

TABLE 1

FIN ANGLE OF INCLINATION (degrees)	FIN LENGTH (inches)	 TYPE 1	 TYPE 2	 TYPE 3	 TYPE 4	 TYPE 5	 TYPE 6
0°	3.5	X	X	(X)	X	X	X
	4.0	X	X	(X)	X	X	X
	6.0	X	X	(X)	X	X	X
	8.0	X	X	(X)	X	X	X
	10.0	X	X	(X)	X	X	X
10°	3.5	X	X				
	4.0	X	X				
	6.0	X	X				
	8.0	X	X				
	10.0	X	X				
15°	3.5			(X)			
	4.0			(X)			
	6.0			(X)			
	8.0			(X)			
	10.0			(X)			
20°	3.5	X	X				
	4.0	X	X				
	6.0	X	X				
	8.0	X	X				
	10.0	X	X				
30°	3.5	X	X				X
	4.0	X	X				X
	6.0	X	X				X
	8.0	X	X				X
	10.0	X	X				X

DIMENSIONS OF FIN SPECIMENS TESTED

Fins of 0.25 inches and 0.375 inches thick for each type were tested. Five specimens of each type were tested.

The method of fabricating the Monserco fins differed in only one respect from that detailed in the ORNL report. Whereas at ORNL, each group of 2 inch (50.8 mm) wide fins were cut out of single 10 inch (254 mm) long weldments, all of the 2 inch wide Monserco fins (except the ORNL replicas) were welded individually from 2 inch strips held in a jig. By applying this method, a considerable saving in the cost for fabrication could be achieved. Only in manufacturing the ORNL replicas, was the same procedure as ORNL used.

The fin test specimen widths and lengths were accurate to within less than 1/16 inch (1.6 mm), and fin thicknesses were approximately 0.010 inches (0.3 mm) over the quoted sizes.

2.4 Performance of Tests

The basic approach to testing was to impact the specimens with sufficient energy to produce a "reasonable" amount of deformation - roughly in the 25% to 50% range. The idea was to repeat the selected test conditions for each group of five specimens to reduce random effects, and obtain from each group two average curves:

(i) Absorbed energy/plastic moment versus percent deformation,
(ii) peak force per unit fin width versus fin height/thickness.

For the assumed relations to be sound, then the curves obtained from all specimens of a particular fin height and angle of inclination should be coincident, at least within the margin of error indicated on the ORNL design curves. Likewise, to conclude that the Monserco results agree with the ORNL data, the curves for the Monserco replicas of the 2 inch wide ORNL fins, the various Monserco double fin configurations and the 10 inch wide fins should also coincide with the ORNL curves.

The execution of each test followed the same routine procedure. A brief description of this procedure has been included in this section, for although there was nothing particularly complicated about it, this description together with the few comments and explanations in the text, should help the reader understand and interpret the various traces and results. Briefly, the sequence of events was as follows:

1) Set the total hammer weight to an appropriate value by adding/removing individual weights. Initially, the ORNL data was used as a guide to selecting the weight for a particular group of specimens, and later, as we gained experience the values from earlier test were used. If the fin deformation obtained on the first specimen in a group turned out to be either excessive or insufficient, the hammer weight would be adjusted and held at that value for the remaining four specimens. On a few occasions when the selected weight was too heavy, the hammer would "bottom out"; that is, after the fin had deformed plastically to its point of maximum deflection, there would still be some residual hammer energy that would have to be absorbed by the load cell. The occurrence of bottoming out is manifested in the load cell traces (Appendix D) by the appearance of a second 'bump' after the end of the initial transient.

2) Set the load cell output to zero with the hammer resting on top. In most cases, this was not really significant because with the appropriate load cell in place and appropriate scale settings on the oscilloscope, the change in load cell output was imperceptable. Where a change was noticeable, this procedure helped to show up the end of the transient more clearly on the load cell trace.

3) Fasten the test specimen in the clamping fixture on top of the load cell. The specimens were all sorted and numbered prior to testing, and the code numbers written on one of the machined inclined faces on the specimen base. Each specimen was put into the fixture from the same side, with the numbered side to the right.

4) Select the appropriate time scale and voltage scales on the oscilloscope, and set the trigger. The scales on each channel were chosen so that the whole of the captured transient would fill the screen, thereby maximizing the resolution of the traces. A certain amount of trial and error was unavoidable as the duration of the transients and the peak responses from the load cell and accelerometer could vary considerably from one group of specimens to another. It is for this reason that the reader will find in a few of the plots of captured load cell transients that the time base is not always the same within a group of similar specimens.

   The oscilloscope was triggered internally on the accelerometer signal, as explained in Appendix A. On the Tektronix 7D20 unit used this project, it was possible to adjust the trigger point on the time scale so that a brief portion of the trace before triggering could also be captured. Generally, the trigger point was set one graticule division in from the left hand edge of the oscilloscope screen; although for a small number of specimens it was set on the left hand edge. The small amount of zero off-set on the load cell and/or noise on this pre-trigger portion of the trace is the cause of the computed energy and displacement being non-zero initially in some cases.

5) Raise the hammer to the required height. With the wide range in stiffness in the 650 fins, it was necessary to vary the drop height as well as the hammer weight to get the energy needed to produce the desired fin deformation in all specimens. From a few preliminary tests, it appeared that the deformation and peak load cell response for a given hammer energy could vary with the fin impact velocity. To minimize any possible influence that a different drop velocity might have, only a few set values of drop height were used, these being chosen such that the impact velocity was a convenient fraction of the impact velocity from 30 feet (9 m). This, and the fact that the hammer weight could be adjusted only in 40 pound (18 kg) increments, meant that it

was not always possible to factor up the hammer energy exactly when going from one particular single fin configuration to its corresponding double or wide fin configuration.

6) Release the hammer.

7) Measure the final deformed height of the fin. This was done by measuring the distance between the top surface of the fin clamping fixture and the bottom surface of the hammer while it still rested on top of the deformed fin specimen. An average value was recorded where the final hammer position was not completely horizontal.

8) Transfer the test parameters (fin identification number, drop height, hammer weight, which load cell and accelerometer was used, deformed fin height) and the oscilloscope header data along with the two digitized traces to the VAX computer.

3.0 TEST RESULTS AND EVALUATION

3.1 Methodology for Processing Test Data

The force versus time and the acceleration versus time traces that were captured during the impact of each specimen were processed to obtain the energy absorbed by the fin(s), the peak load and the percent vertical fin deformation. This was done by applying the same method as that used by Davis in the ORNL report, and although his report does present an explanation of the methodology and a listing of his program, a brief description of the algorithm is included in this section. Appendix C contains a Fortran listing of the pertinent subroutines used to compute the above results on a VAX 11/750 computer.

Output from the digitizing oscilloscope comprised two strings of 1024 discrete values of voltage from the load cell and the accelerometer. The time interval between these values remained constant throughout the transient and was determined by the setting of the time base dial. The first step was to convert the load cell output from volts to force by multiplying by the load cell calibration factor.

$$f_{LC} = f_i \times y_{mult}$$

The acceleration of the hammer at each point in the load cell transient was obtained by dividing by the hammer weight.

$$a_{LC} = f_{LC}/W \times g$$

The initial impact velocity of the hammer was easily computed from the relation

$$v_o = \sqrt{2gh/12} \qquad \text{(ft/sec)}$$

and the mean acceleration between successive sample times as

$$\bar{a} = (a_{i-1} + a_i)/2$$

To get the energy absorbed in the time interval between sample voltages, the fin displacement δx in that time interval by adding the incremental displacements.

$$E_i = E_{i-1} + \delta x\ (f_{i-1} + f_i)/2 \qquad \text{(in-lb)}$$

$$\text{where} \quad \delta x = (v_o dt + 1/2\ \bar{a}\ \delta\ t^2)12 \qquad \text{(inches)}$$

The deformation history of the fin was calculated by adding the incremental displacements throughout the transient.

The same method was also applied to process the accelerometer output data.

3.2 Presentation of Results

Test results derived from each test specimen are tabulated in the Tables included in the back of this report. Both the plots and the tables are grouped by specimen type and size. The tables list the basic test parameters (drop height and hammer weight), the measured vertical deformation and some derived results. The derived results that are tabulated are those that were used to generate the characteristic curves in the ORNL report, namely absorbed energy divided by the plastic moment, the percent vertical fin deformation and the peak force divided by the fin width.

The plastic moment values used were calculated from the expression

$$M_p = \sigma_y \, (bt^2/4)$$

where M_p = static plastic moment of specimen
σ_y = yield stress of specimen material
b = width of fin
t = thickness of fin

For the specimens that had two or three fins, the value for the plastic moment used was double or three times that of the same-sized single fin. With regard to the value for the yield stress used in calculating the plastic moment, it should be remembered that whereas the ORNL data used a nominal value of 30 ksi (207 MPa), higher (actual) values of 41.4 ksi (285 MPa) and 39.9 ksi (275 MPa) were used to obtain the results in this report.

3.2.1 Key to Fin Specimen Identification Numbers

At this point it would be helpful to explain the key to the specimen identification numbers, to make it easier for the reader to interpret the data contained in the tables and plots. Each test specimen is identified uniquely by a five digit number which specifies 1) the fin type, 2) the fin thickness, 3) the length (height) of the fin, 4) the angle of inclination and 5) the sample number in a batch of five specimens. The code for the specimen identification number is as follows:

FIRST CHARACTER : 1 - Wide Single Fin
2 - Double Parallel Fins
3 - Triple Fins
4 - Double Converging Fins
5 - Double Braced Fins
6 - ORNL Type Fin

SECOND CHARACTER : 2 - Fin Thickness = 0.25" (6.4 mm)
3 - Fin Thickness = 0.375" (9.5 mm)

THIRD CHARACTER : 3 - Fin Length (Height) = 3.5" (8.89 cm)
4 - Fin Length (Height) = 4.0" (10.16 cm)
6 - Fin Length (Height) = 6.0" (15.24 cm)
8 - Fin Length (Height) = 8.0" (20.32 cm)
1 - Fin Length (Height) = 10.0" (25.4 cm)

FOURTH CHARACTER : 0 - Angle of Inclination = 0 degrees
1 - Angle of Inclination = 10 degrees
2 - Angle of Inclination = 20 degrees
3 - Angle of Inclination = 30 degrees

FIFTH CHARACTER : 1 to 5 - Fin Sample Number

So, for example, number 12113 identifies the specimen 3 in the group which is of type "Wide Single Fin", thickness 0.25 inches, height 10 inches and 10 degrees angle of inclination.

In the plots of the load versus time, where the traces of the 5 specimens in each group are superimposed on one graph, the last character of the identification number has been omitted from the plot heading.

3.2.2 Accelerometer Data

Unlike the ORNL test results, the measurements reported here do not show a good correlation between absorbed fin energy calculated from the load cell and that calculated from the accelerometer. This appears to be due to the tendency for the accelerometer to produce oscillations about a varying non-zero level - a condition that could not be neutralized by adjustment within the accelerometer power supply unit nor by conditioning the output signal with a low-pass filter.

The accelerometer traces were all captured and stored, and were useful in that they were used to trigger the oscilloscope, but the results derived from the raw accelerometer data are not reliable.

3.3 Evaluation of Results

3.3.1 Factoring of Single Fin Data and Correlation with ORNL Curves

The characteristic curves derived by ORNL were obtained by computing the absorbed energy/plastic moment as a function of (computed) percent deformation for fins of various dimensions. A second set of curves was also developed for the peak load versus slenderness ratio (fin length/thickness). Curves similar to the ORNL design curves were generated for the multiple fin and the wide fin specimens.

Each of the load cell traces was therefore processed to obtain the absorbed energy/plastic moment at discrete values of fin deformation from 5% to 50%. Results of the mean values for each group of 5 fin specimens and the standard deviation for that group at each point are tabulated in groups of similar fin length and angle of inclination. The mean values presented in the tables have been plotted in Figures 3 to 22 and a curve (dotted line) drawn through them. The range of scatter of the computed mean values is indicated by the vertical lines. Although the dotted line curve is not drawn through precisely determined average values at each percent deformation, it indicates that these points do indeed lie approximately on one line.

These sets of data seem to indicate that it is reasonable to factor up the energy/plastic moment for multiple fins and wide fins.

However, as can be seen from the ORNL curves that are superimposed on the plots in Figures 3 to 24, the results reported here differ quite considerably from them, particularly for the vertical fins. Some of this discrepancy might be accounted for by using a higher value for the yield stress and imprecise values of fin width and thickness in computing the plastic moment, but in most cases this is insufficient. In many cases, particularly for the vertical fins, the ORNL curves show a much steeper trend for increasing deformation. In general, the results reported here indicate that the ORNL data is optimistic in predicting the amount of energy/plastic moment for deformation over 20%.

Peak loads for the specimens are tabulated in the results and also plotted against the slenderness ratio, in Figures 23 to 26. The data shows a considerable amount of scatter, a marked variation from the ORNL curves, particularly for the vertical fins, and some distinction between peak loads for fins of the same type but different thickness. These results raise a question whether the peak force per fin width for slenderness ratios greater than 10, may be a lot higher than the ORNL curves indicate - particularly for the vertical and near vertical fins.

3.3.2 Failure Modes

It is clear from the results presented here that ORNL's observation that the vast difference between the energy absorbing capabilities of the various specimens is due to the specimen failure mode - a fin failing by double- or triple-hinge mode absorbs more energy than a single-hinge failure. Although vertical fins almost always fail by the same mode, ie double- or triple-hinge, there can be a considerable difference in the amount of the final deformation, depending on how near to the contact surface of the fin the buckling curvature occurs. The final deformation is smaller if the fin curls near the top than if the curve is lower down the fin. While this might be straight-forward, it is not obvious that the point of curvature can be predicted, and hence the deformation, with any certainty.

For the fins with angles of inclination of 20 and 30 degrees, the failure mode is almost always the same, ie single-hinge bending type failure. The statement that there is a transition point between single- and double-hinge modes that lies between 10 and 20 degrees of inclination is not born out by these results. The 10 degree fins tested here failed in both modes, so it is probably more accurate to say that there is a range of inclination angles for which the failure mode may be double- or single-hinge. However it does not appear that there is a simple rule that could be extracted from the data to predict the failure mode.

4.0 CONCLUSIONS

It appears reasonable to assume that energy/plastic moment versus percent deformation curves may be factored pro-rata with length and number of fins. However, since the results obtained do not show good correlation with all of the ORNL curves, caution should be applied in doing the pro-rating, at least until further detailed analysis of the data has been done.

While peak force per fin width generally decreases with increasing slenderness ratio, the peak forces for a given slenderness ratio (fin height/thickness) above 10 can be significantly higher (double) than indicated by the ORNL curves. The sharp upward trend in the ORNL curves for slenderness ratios below 10 was not verified by the results obtained in these tests.

The deflected shapes do not indicate a general rule of failure other that for angles of inclination between 0 and 10 degrees, the failure mode will most probably be by double- or triple-hinge failure (buckling), and for 20 degree and greater the failure mode will most likely be single hinge (bending).

4.1 Recommendations

While the results presented in this report do answer an important question by verifying one of the assumptions inherent in the ORNL design curves, they however, raise another question by not showing agreement with the values given by the ORNL curves. Due merely to the fact that the ORNL data has been around for some fourteen years and has probably been used in many crush limiter designs, the burden of proof would seem to lie with the new data presented here. With this in mind from the beginning of the test programme, much care was taken to control the test conditions, to eliminate systematic errors and to minimize random effects. The consistency obtained in most of the load cell traces and fin deformations, indicate that this indeed has generally been achieved. The computed variances included in the tables show a high degree of consistency for most groups of specimens. Some of the scatter indicated by the larger varances may be attributable to the method used to calculate the deformation history from the transients as this is very sensitive to the starting point for integration. A curve fitting technique should significantly reduce the apparent scatter and should be done to substantiate the accuracy of these results. Time and budget constraints limited further work in this direction.

The data presented here and that in Davis' ORNL report apply only to a specific material and fin geometry. Further testing on fins of different geometry and materials would be most useful to both regulatory staff and designers. The ultimate development of an analytical model would be a useful contribution to the technology.

To enhance the value of the research work reported here, it is recommended that further work be done in the following areas:

1) Apply a better numerical method for processing the test data from the experimental work reported here to reduce the scatter in the curves.

2) Test the performance of more fins of
    a) the same geometry but impacted at an angle inclined to the base
    b) different fin geometries that more closely resemble some of the actual configurations currently used
    c) different materials

3) Develop a simple analytical model of a crush limiting fin, test it against the experimental data and then use it to generate design curves or evaluate licencee applications.

4) Extend the R & D work to other types of crush limiting devices - for example, designs that use a foam sandwich overpack. The regulation and approval of such designs cannot be done effectively without an adequate data base.

REFERENCES

(1) Davis, F.C., "Structural Analysis of Shipping Casks. Vol. 9. Energy Absorption Capabilities of Plastically Deformed Struts Under Specified Impact Loading Conditions", ORNL TM-1312, Vol. 9, February 1971.

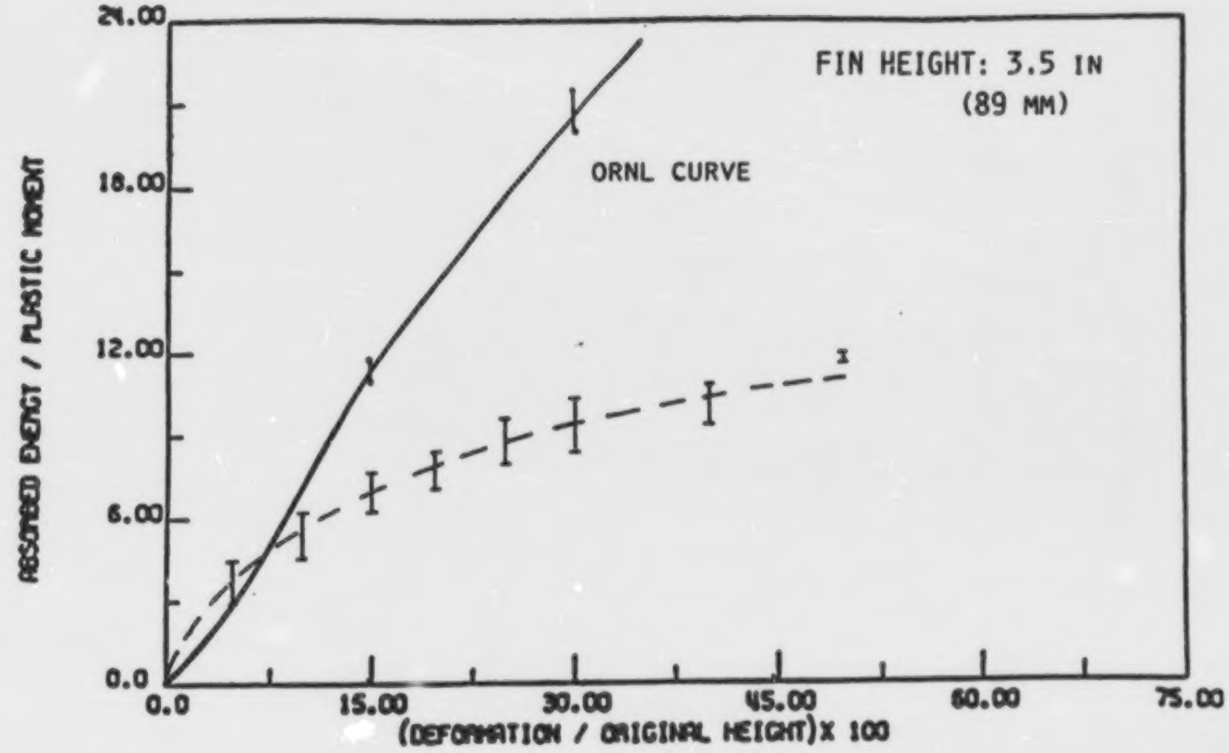


FIGURE 3

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

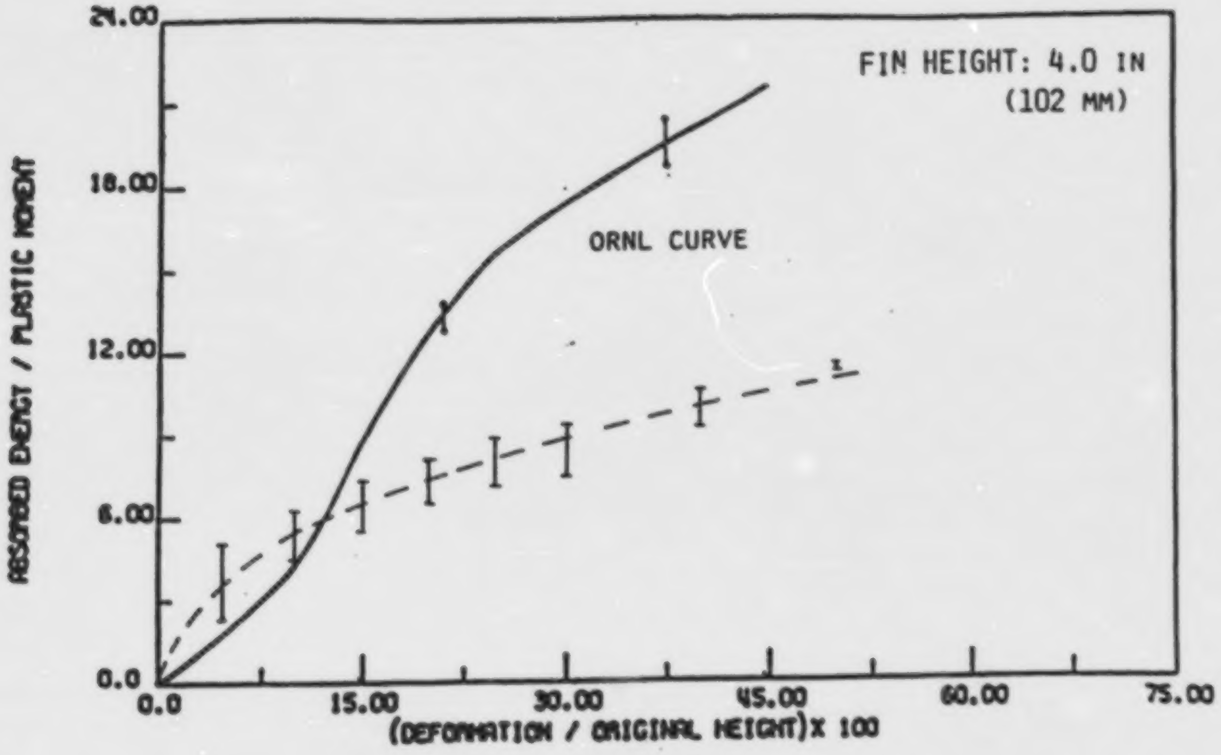


FIGURE 4

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

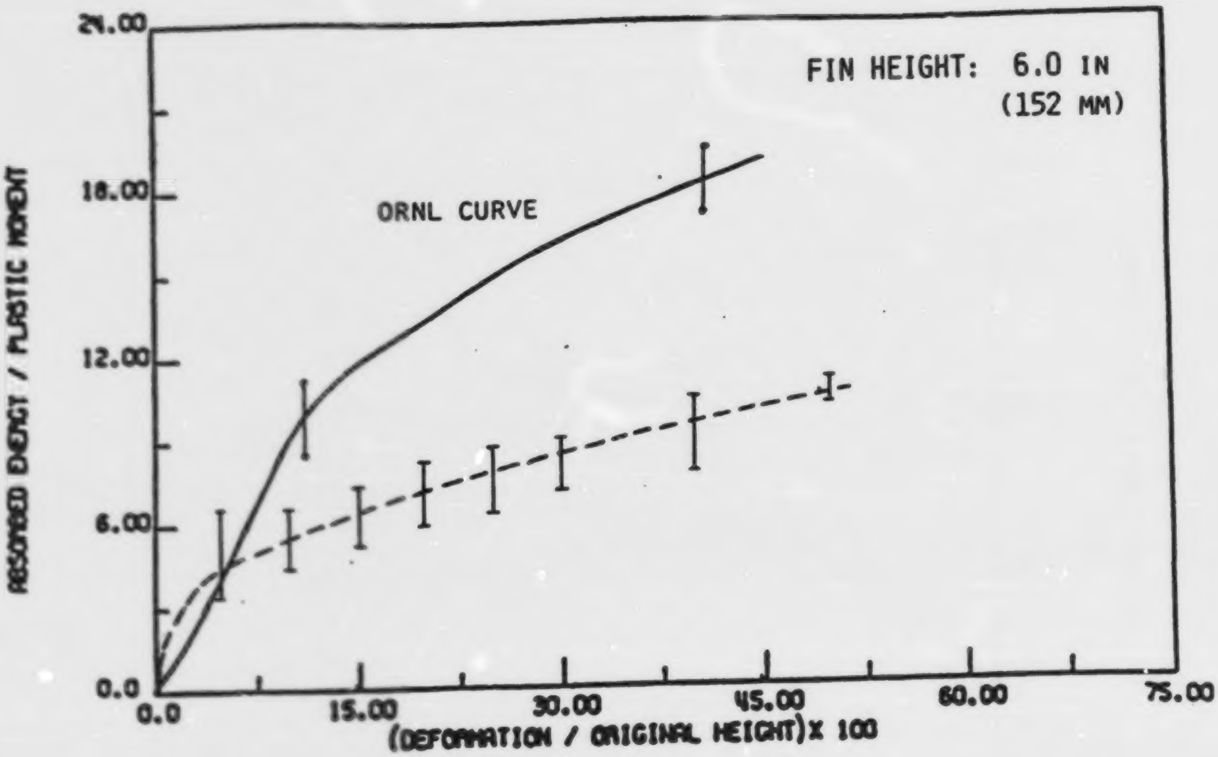


FIGURE 5

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

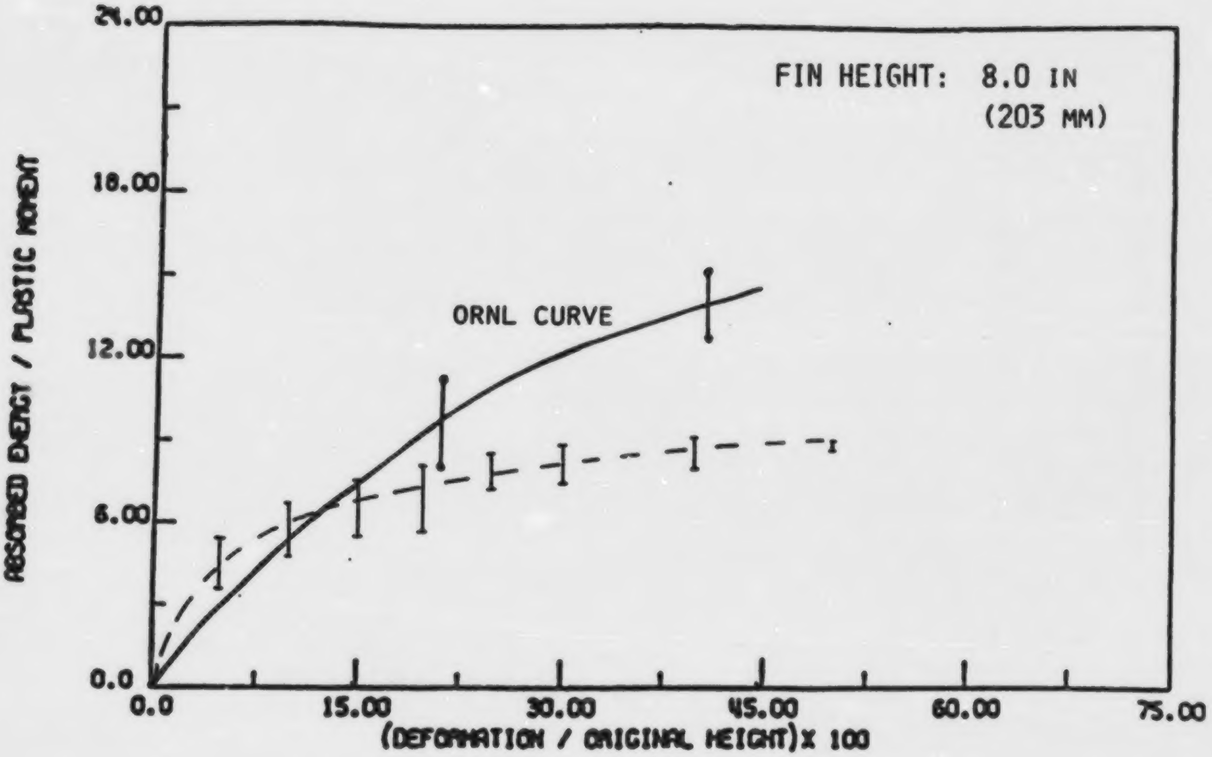


FIGURE 6

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

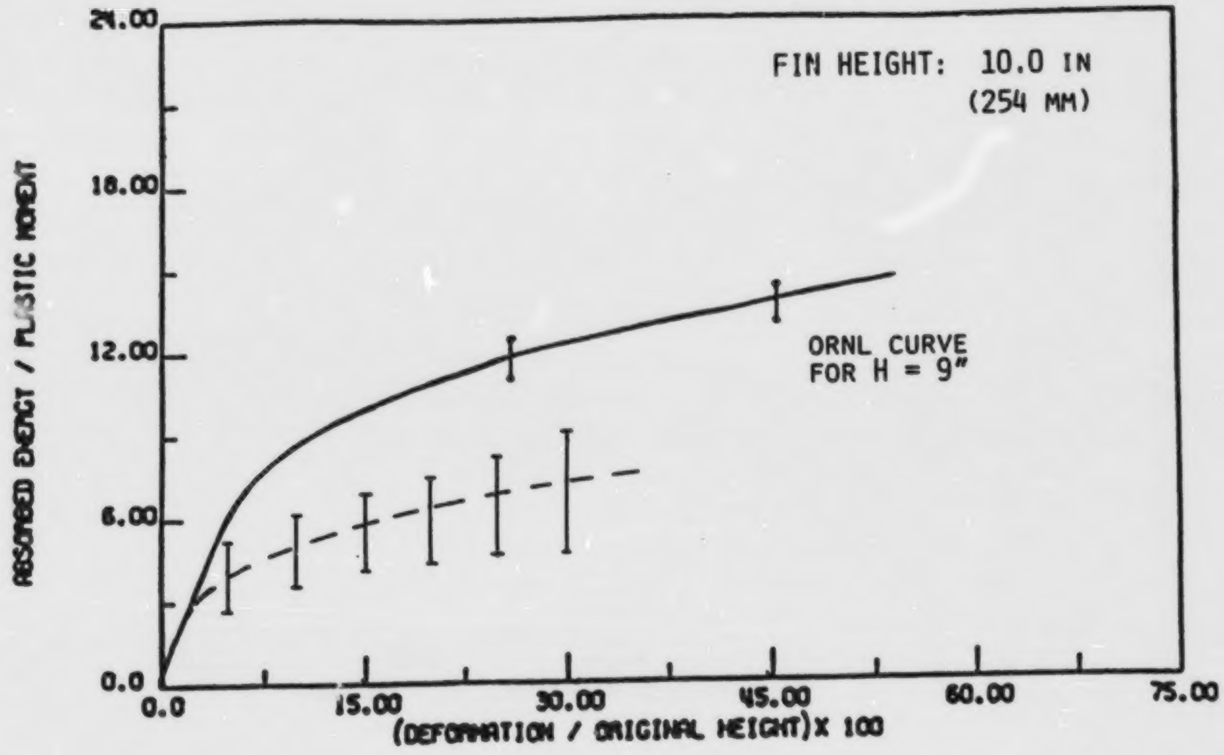


FIGURE 7

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

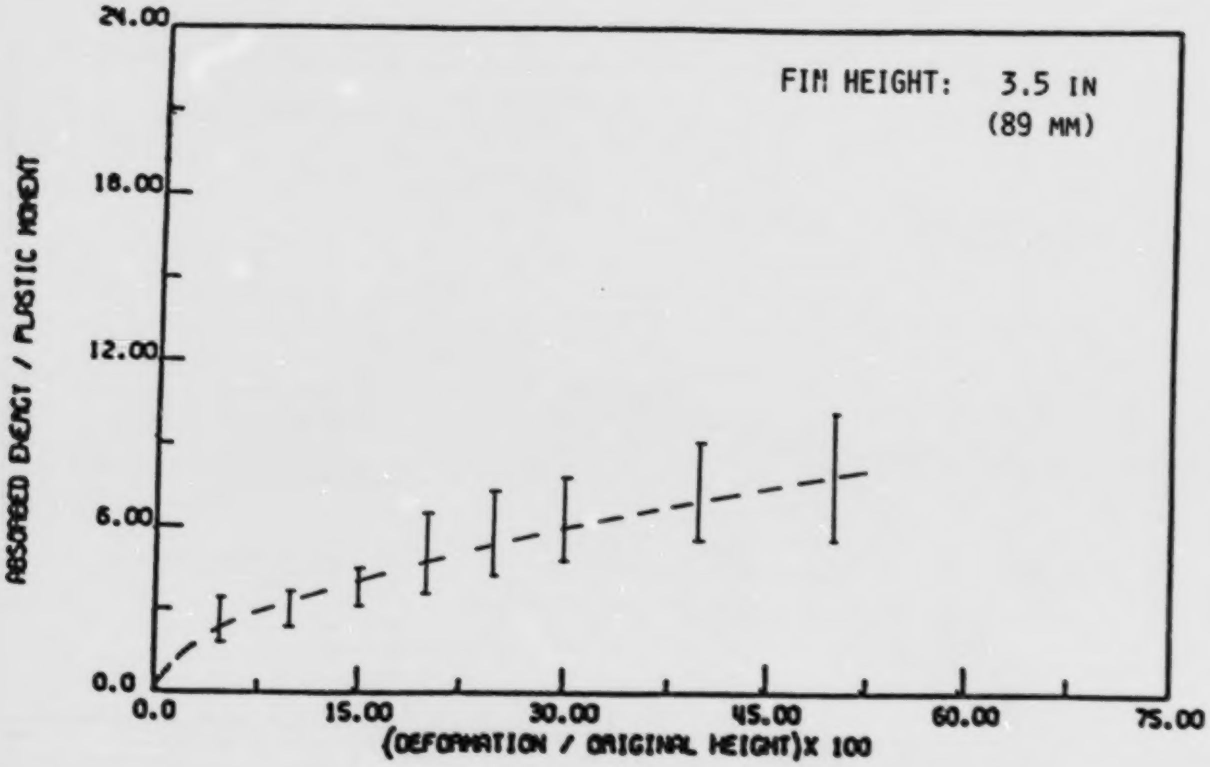


FIGURE 8

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a TEN-Degree Angle of Inclination.

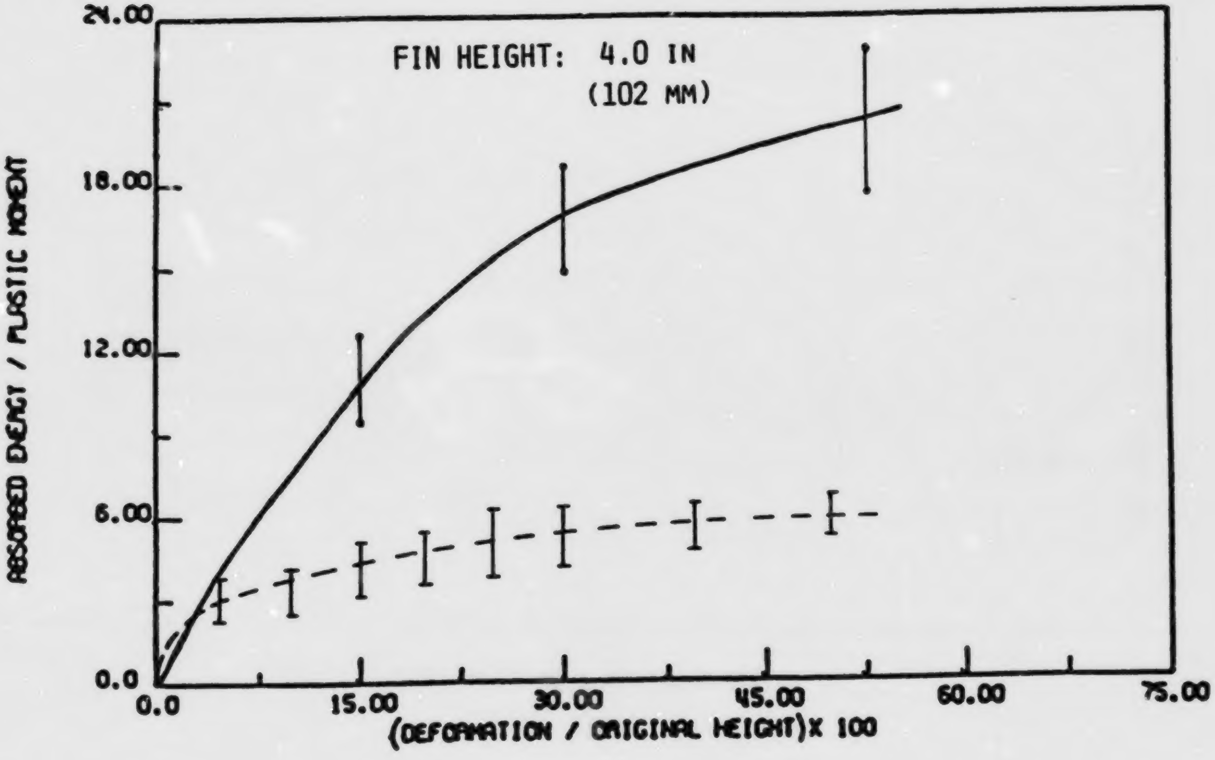


FIGURE 9

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a TEN-Degree Angle of Inclination.

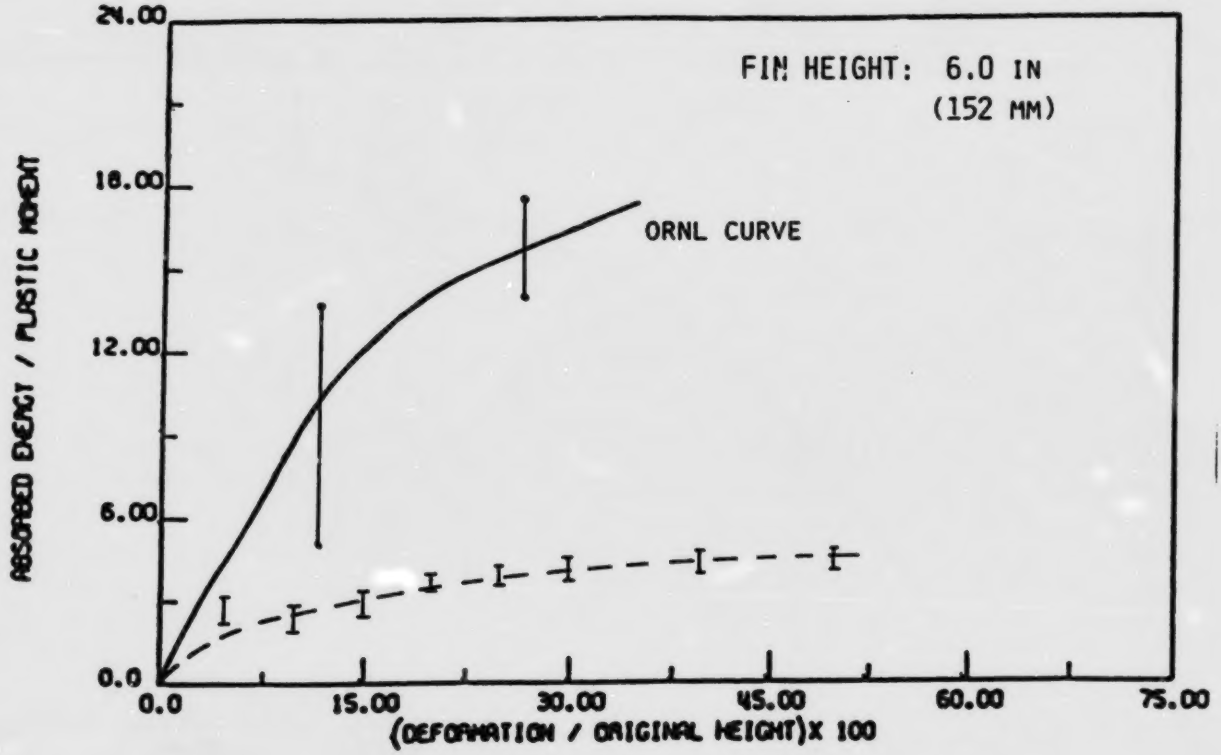


FIGURE 10

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a TEN-Degree Angle of Inclination.

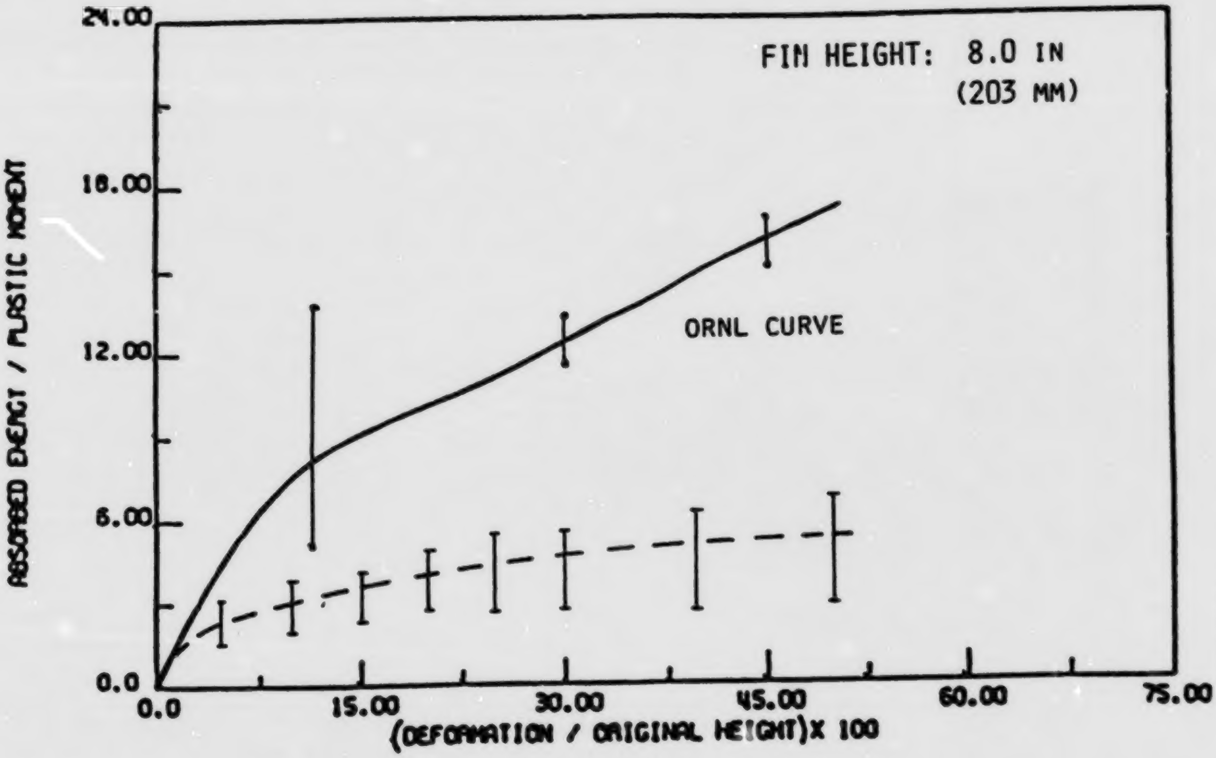


FIGURE 11

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a TEN-Degree Angle of Inclination.

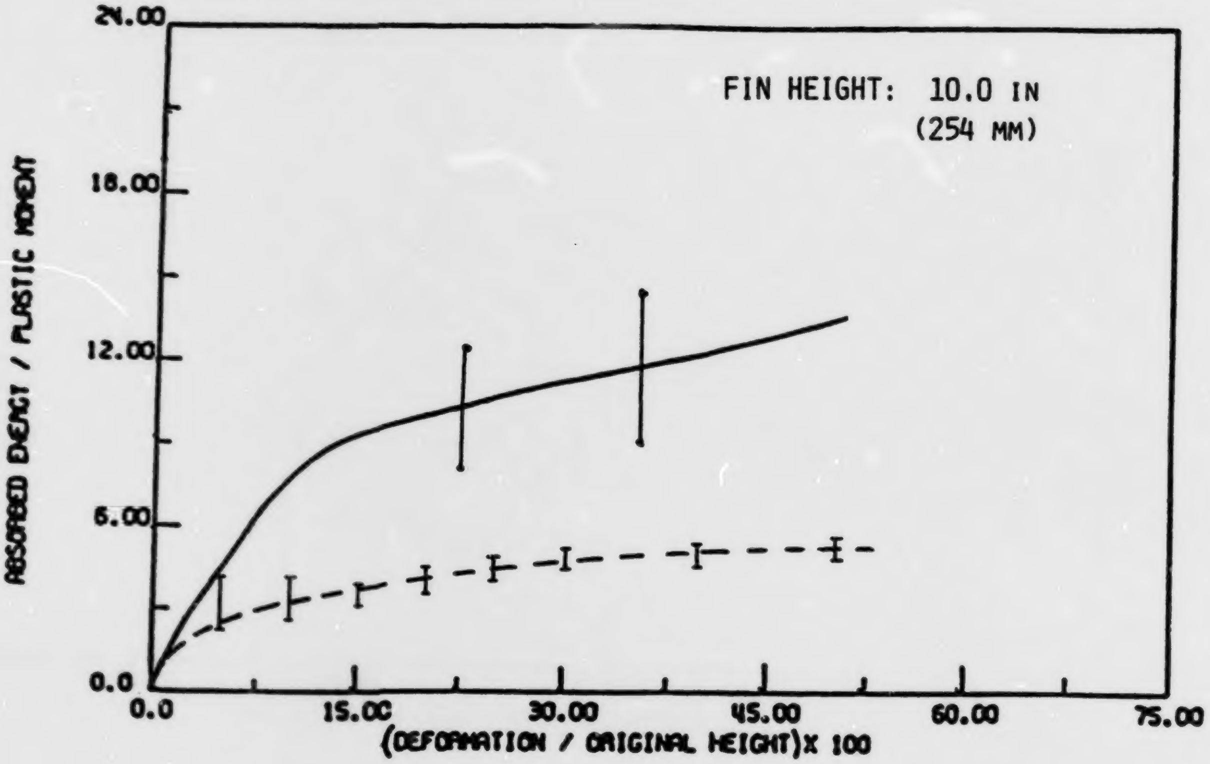


FIGURE 12

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a TEN-Degree Angle of Inclination.

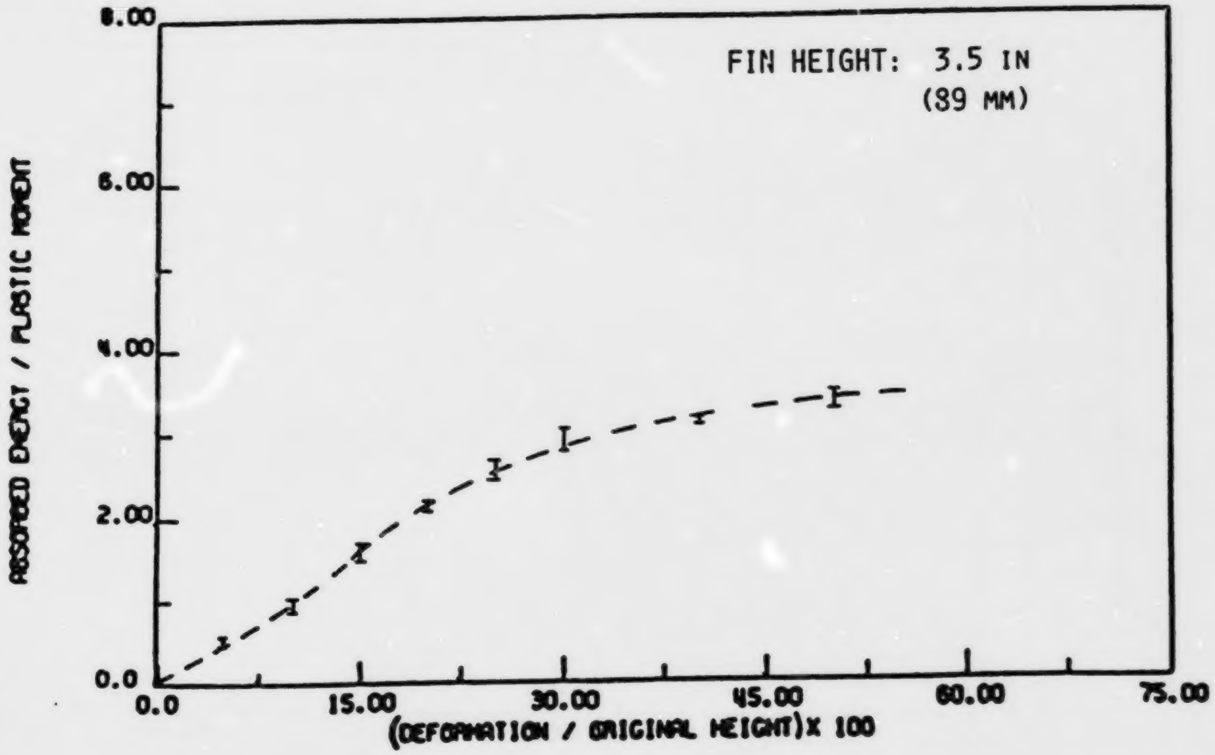


FIGURE 13

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a TWENTY-Degree Angle of Inclination.

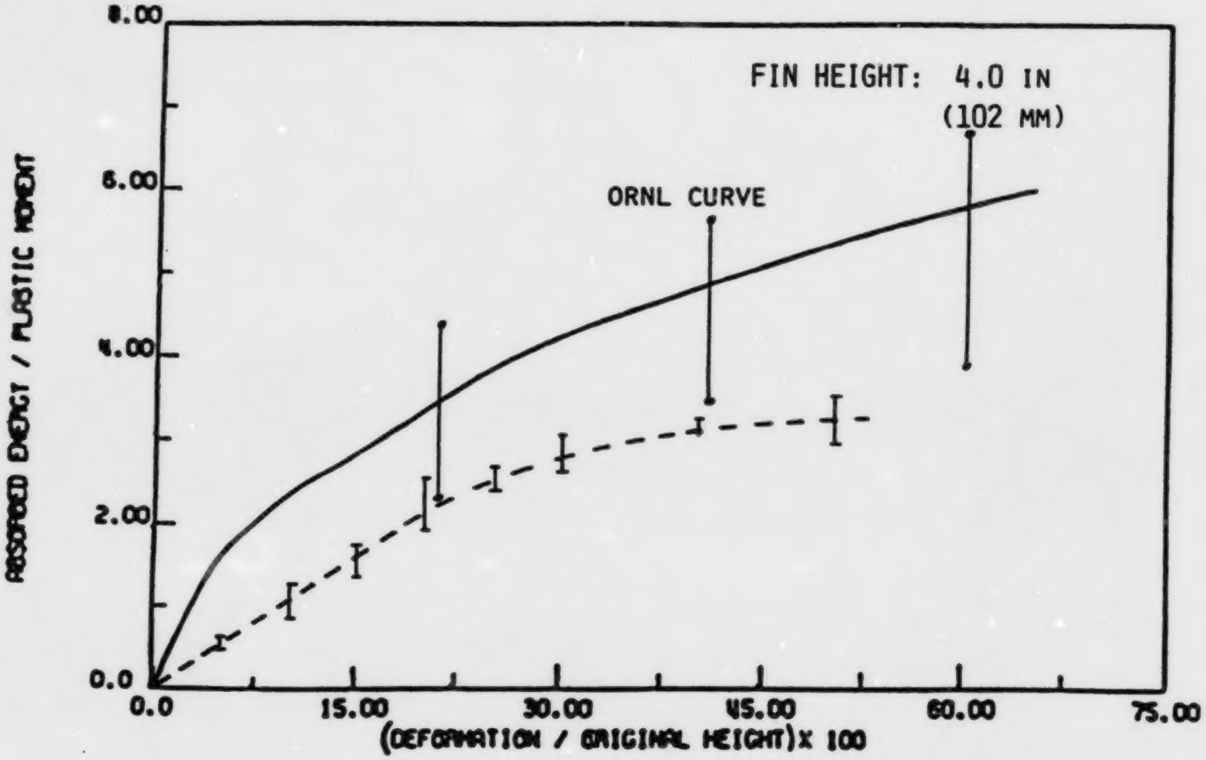


FIGURE 14

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a TWENTY-Degree Angle of Inclination.

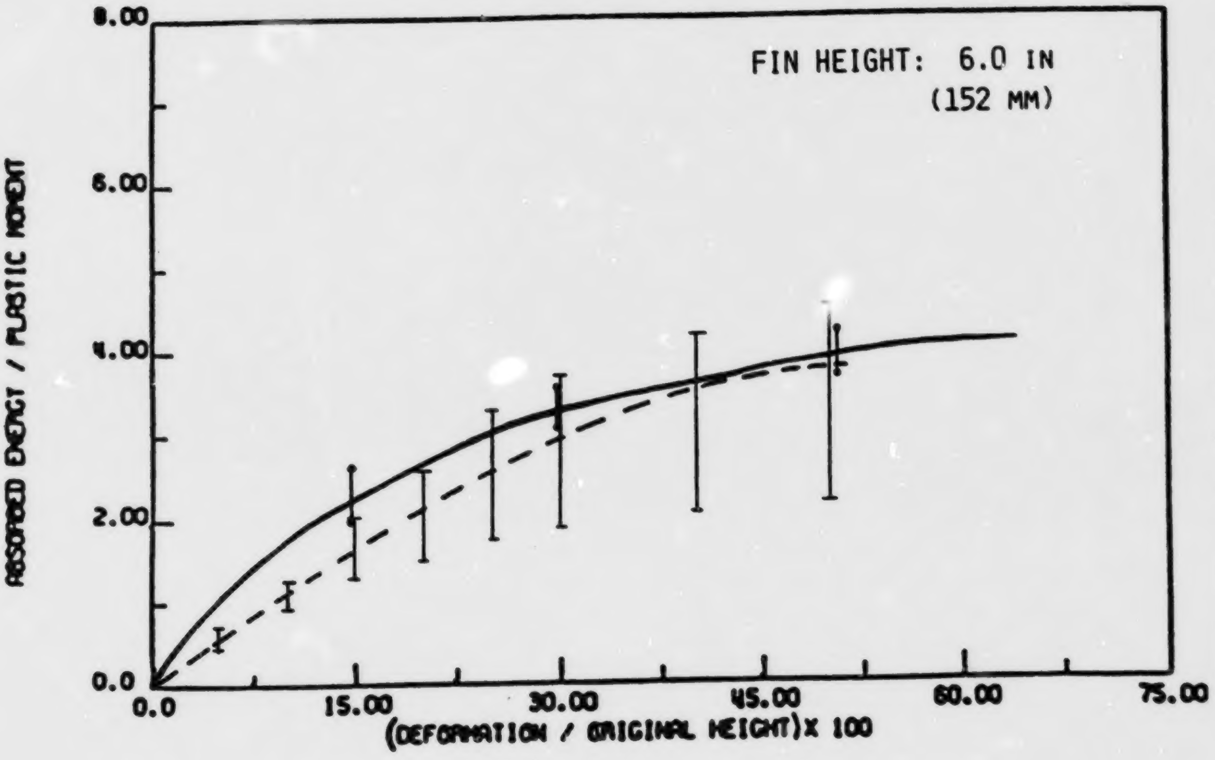


FIGURE 15

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a TWENTY-Degree Angle of Inclination.

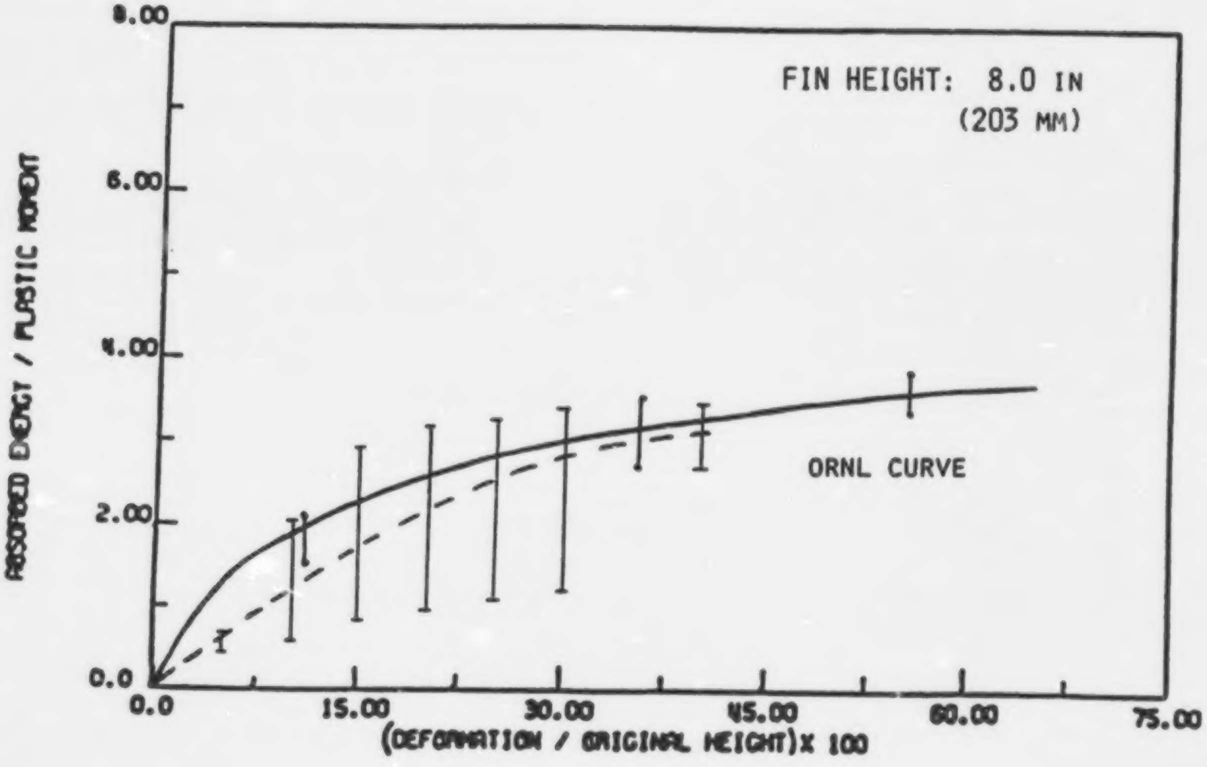


FIGURE 16

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a TWENTY-Degree Angle of Inclination.

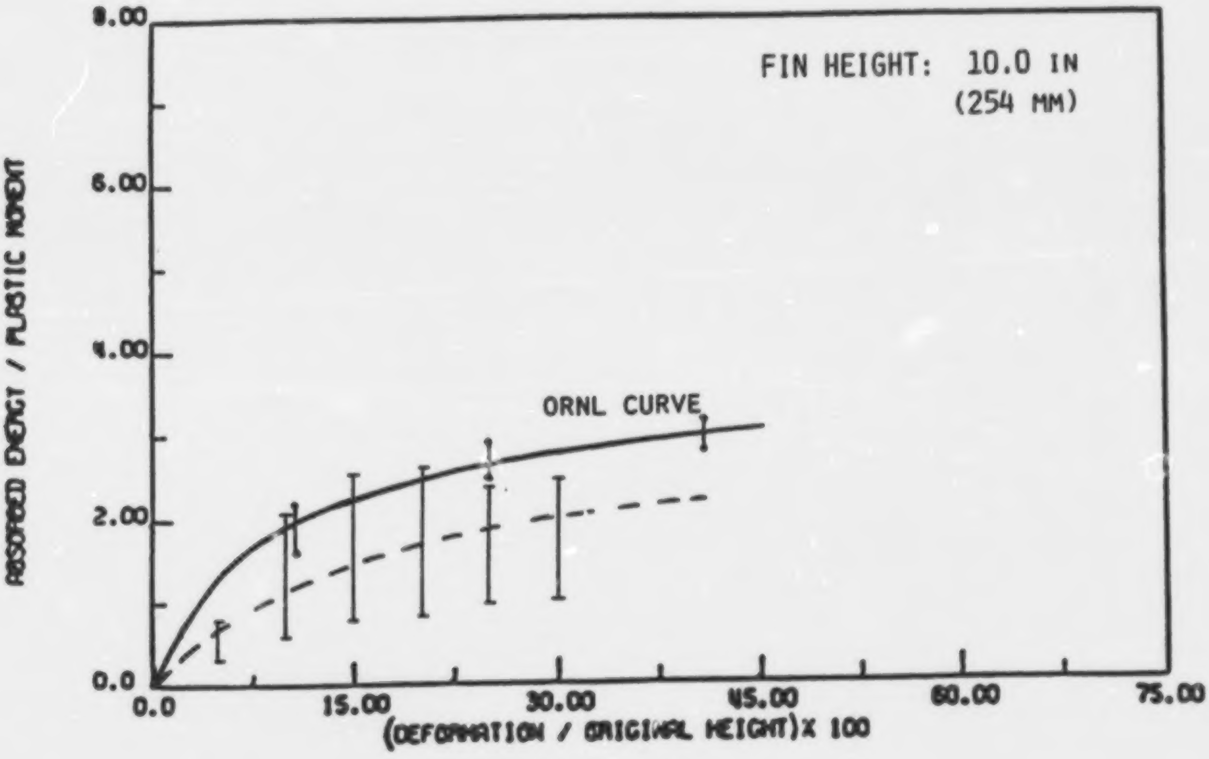


FIGURE 17

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a TWENTY-Degree Angle of Inclination.

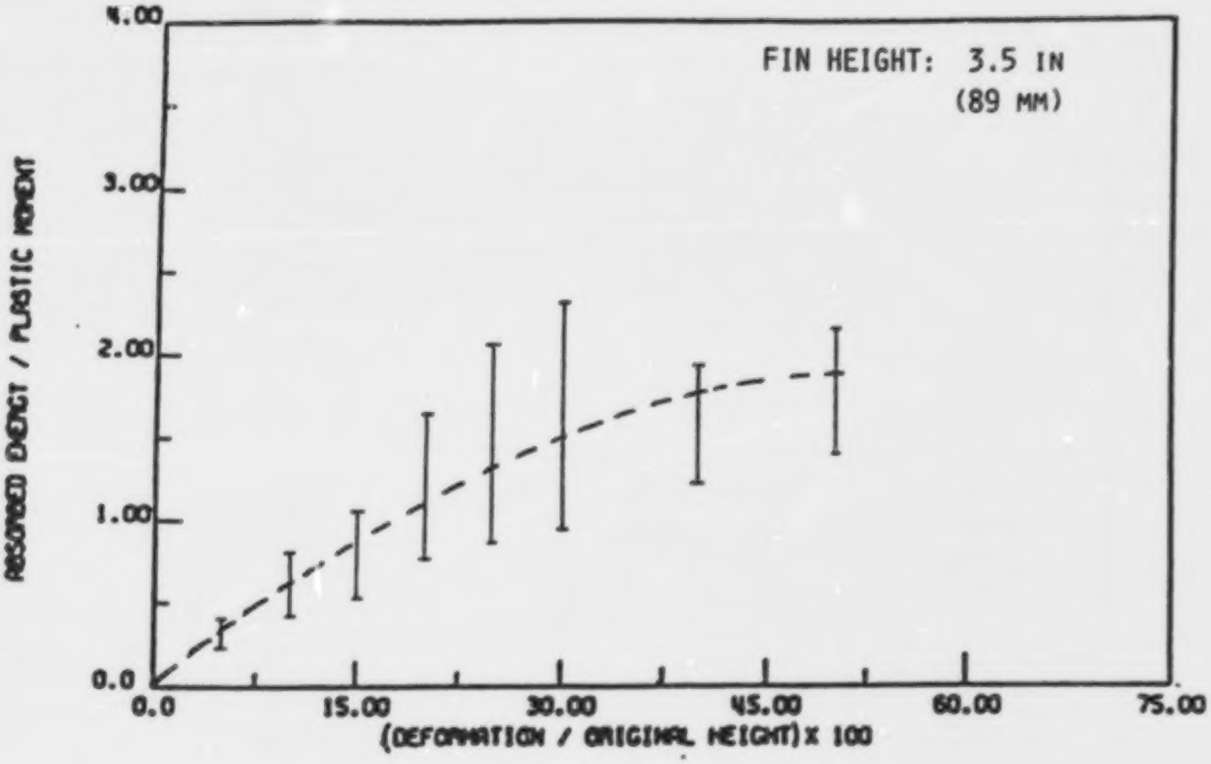


FIGURE 18

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a THIRTY-Degree Angle of Inclination.

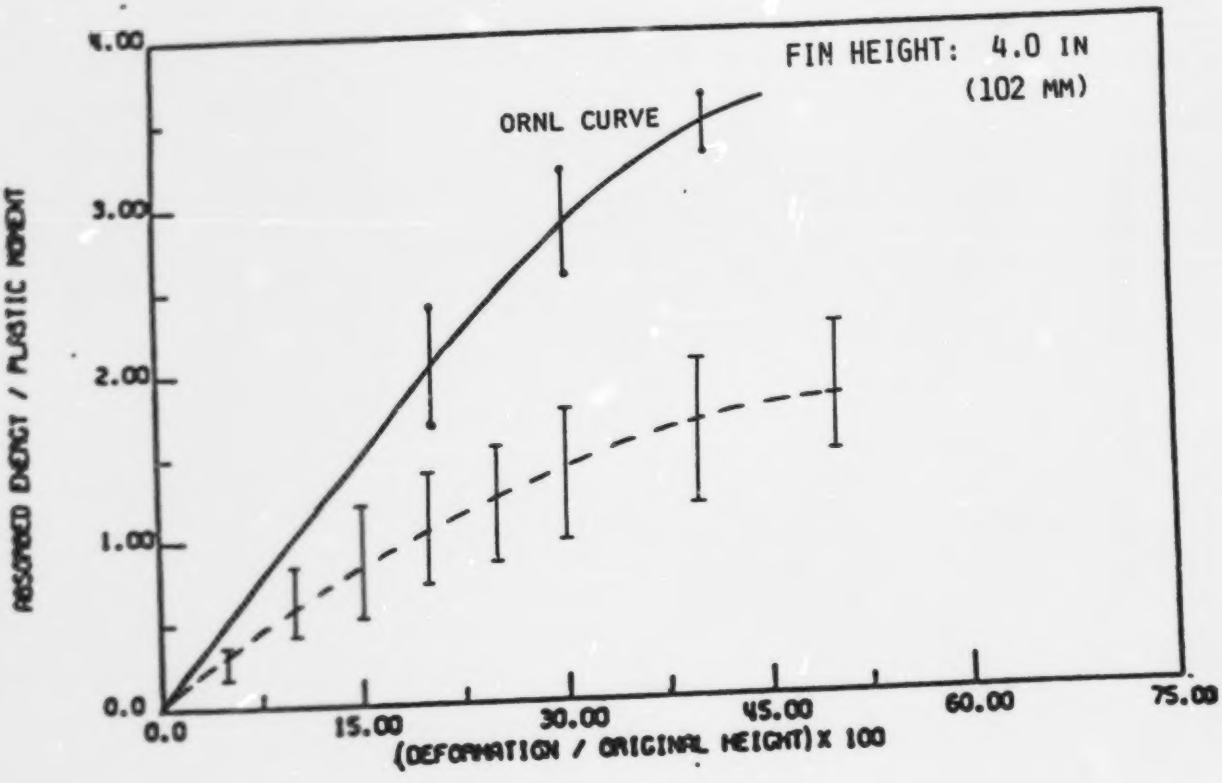


FIGURE 19

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a THIRTY-Degree Angle of Inclination.

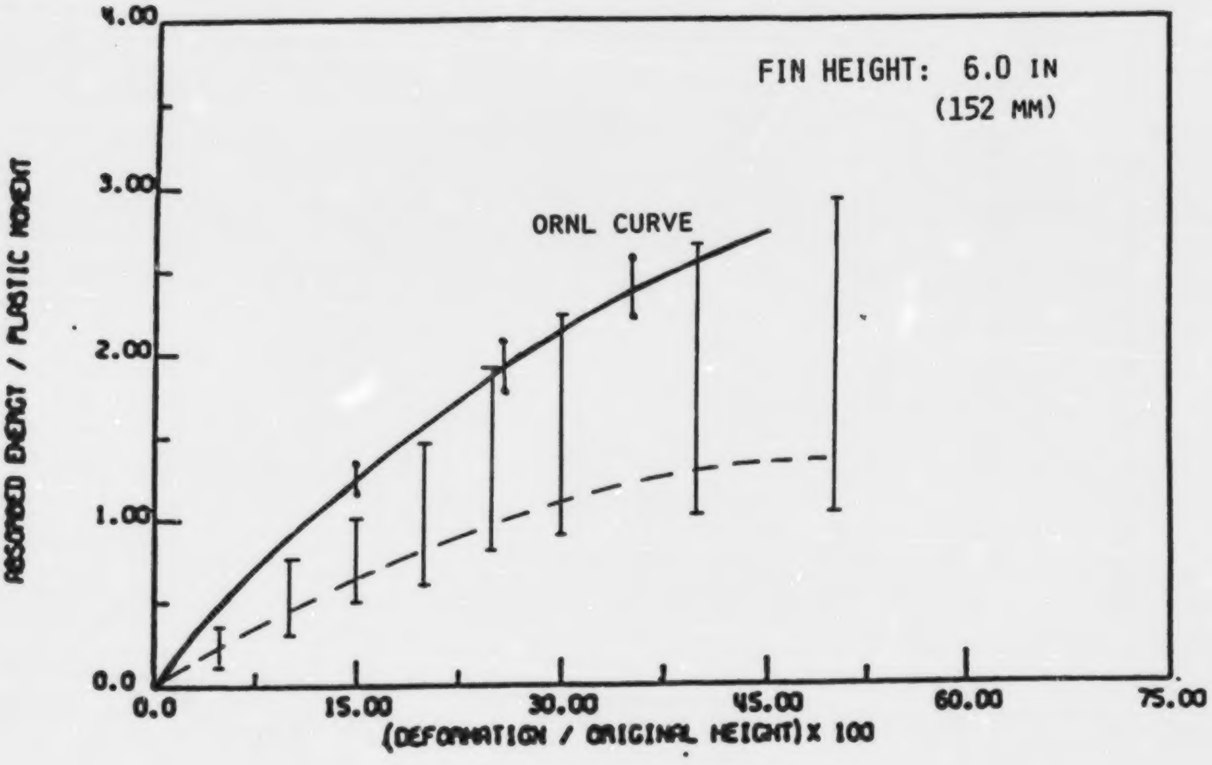


FIGURE 20

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a THIRTY-Degree Angle of Inclination.

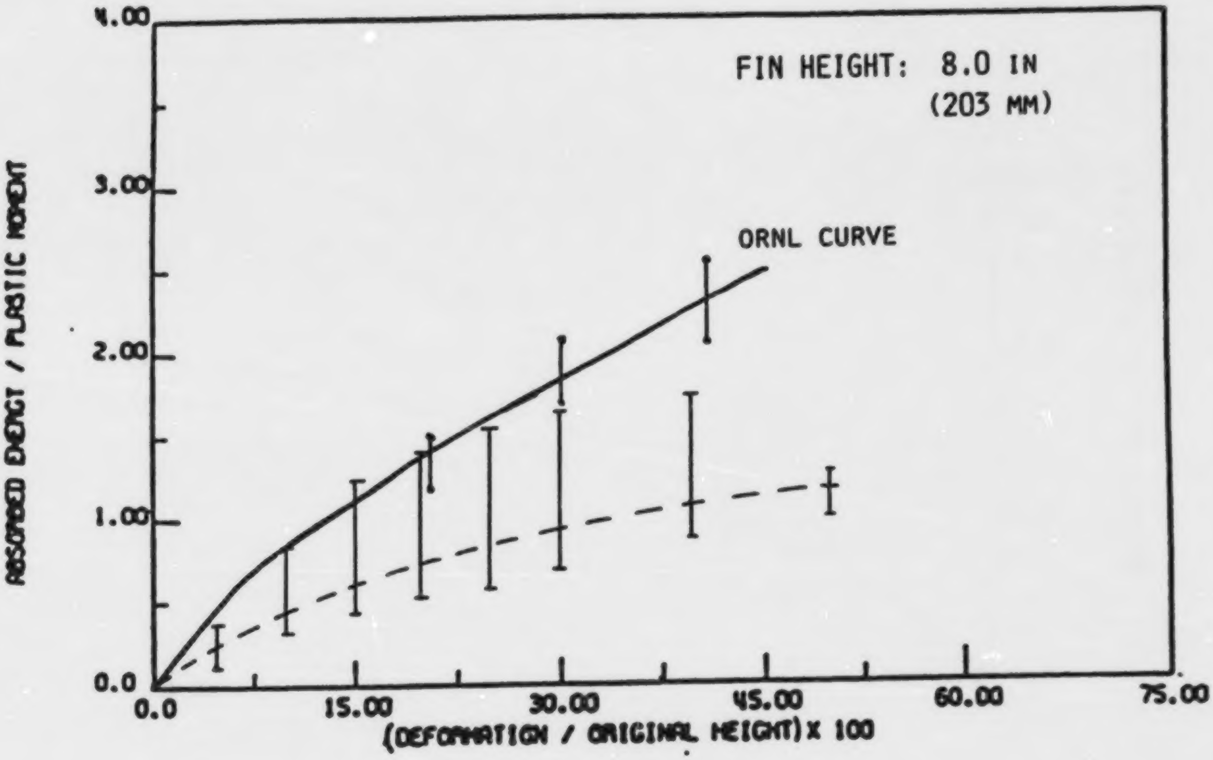


FIGURE 21

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a THIRTY-Degree Angle of Inclination.

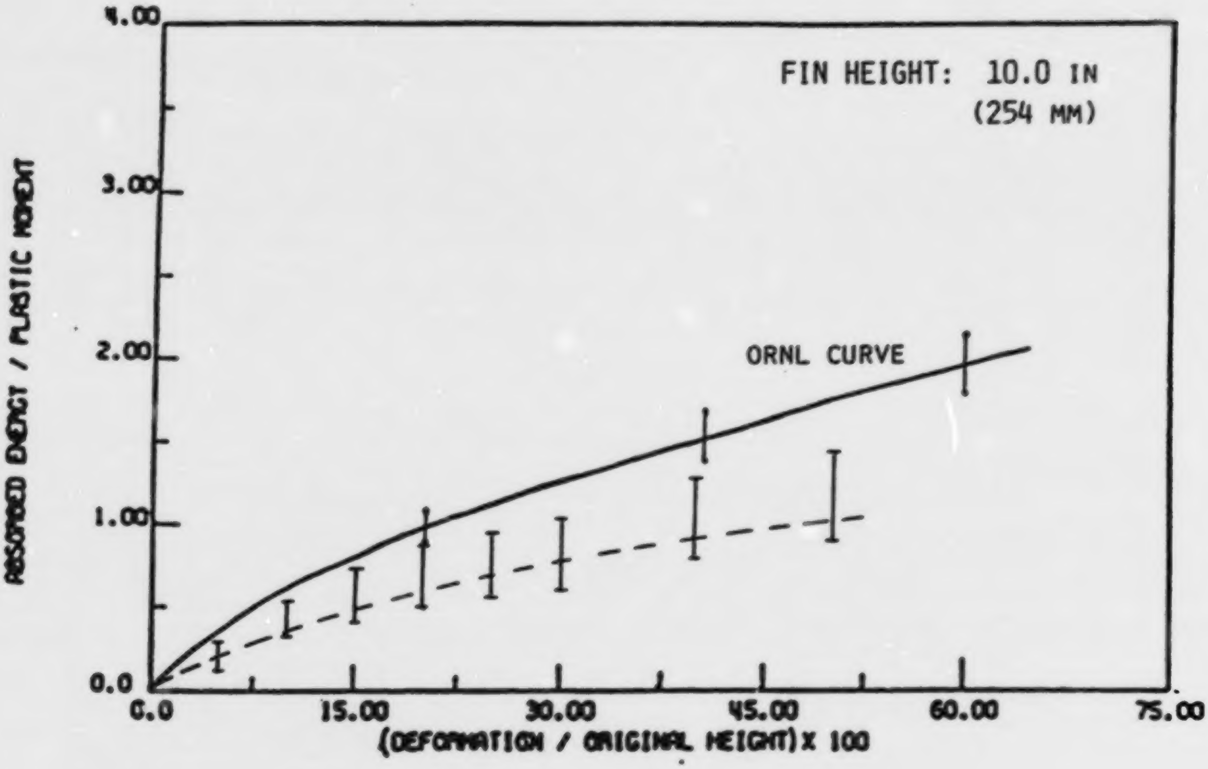


FIGURE 22

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a THIRTY-Degree Angle of Inclination.

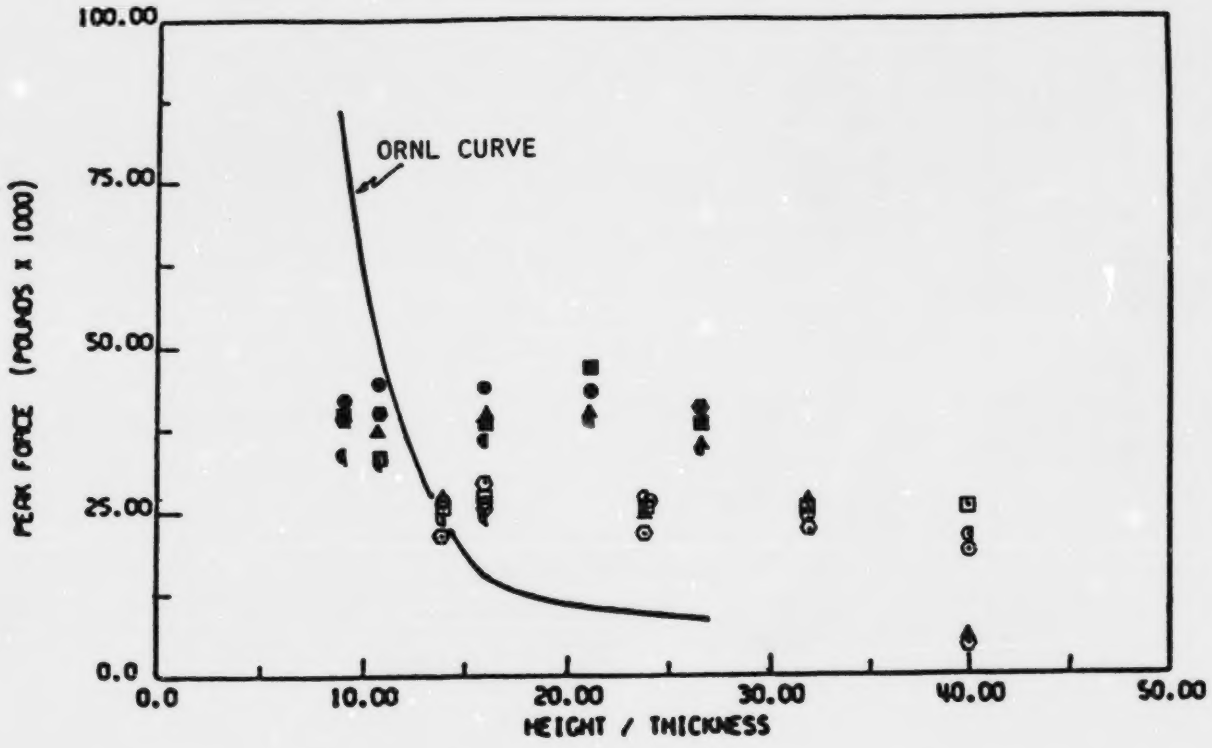


FIGURE 23

The Peak Force Derived From Load Cell Test Data as a Function of Specimen Height Divided by Thickness for Impact Specimens With a ZERO-Degree Angle of Inclination.

PLOT LEGEND

WIDE SINGLE FIN	⊙ (0.25" thick)	● (0.375" thick)
DOUBLE PARALLEL FINS	▲ (0.25" thick)	▲ (0.375" thick)
DOUBLE CONVERGING FINS	⊡ (0.25" thick)	■ (0.375" thick)
DOUBLE BRACED FINS	◐ (0.25" thick)	◖ (0.375" thick)
OAK RIDGE FIN	⊙ (0.25 thick)	● (0.375" thick)
	(6.4 mm)	(9.5 mm)

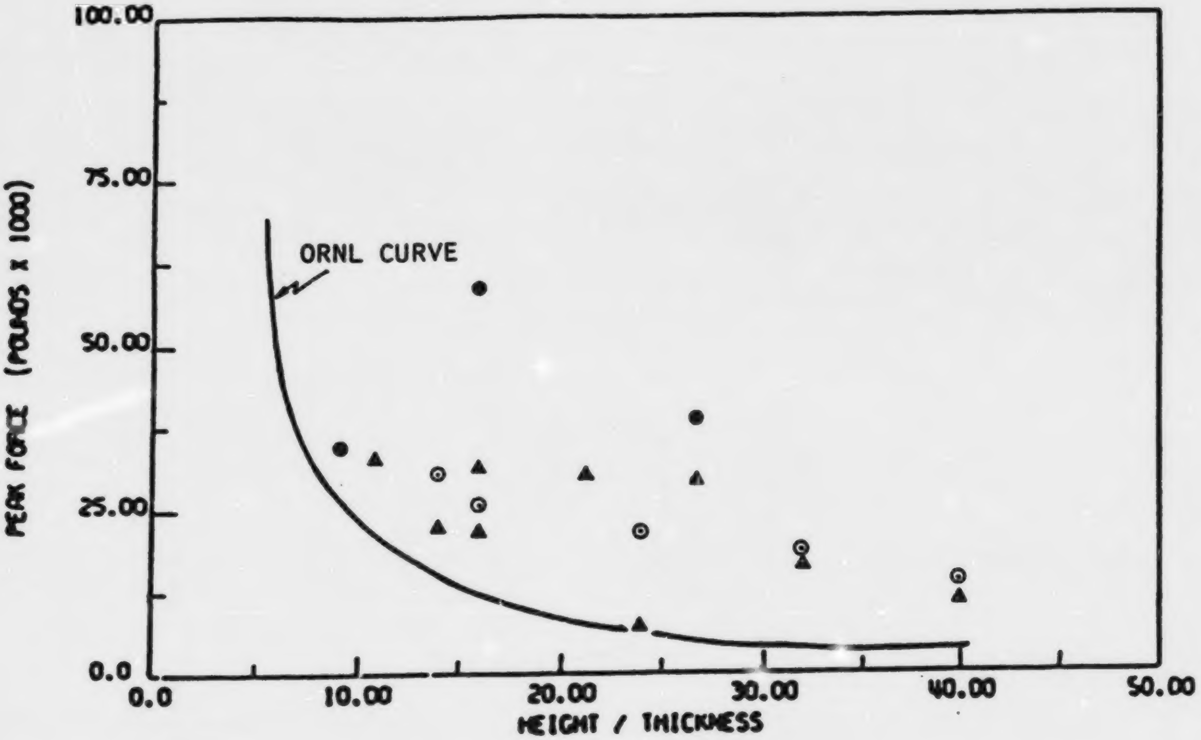


FIGURE 24

The Peak Force Derived From Load Cell Test Data as a Function of Specimen Height Divided by Thickness for Impact Specimens With a TEN-Degree Angle of Inclination.

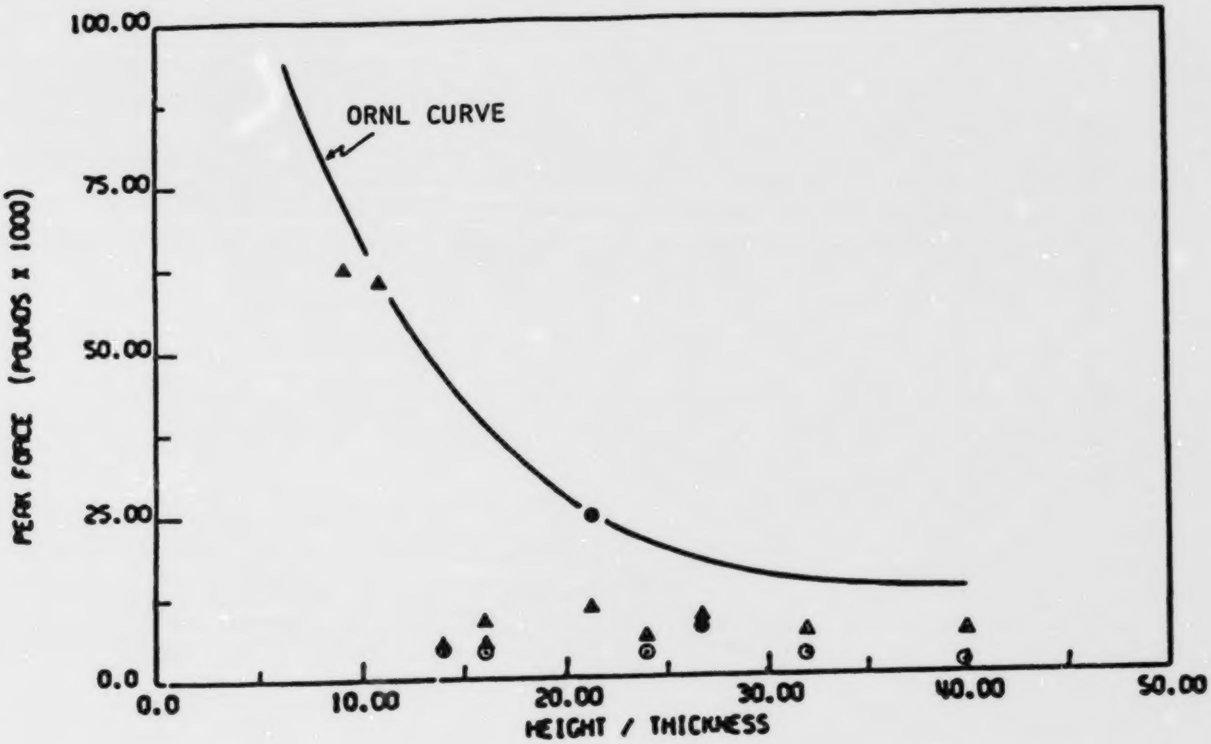


FIGURE 25

The Peak Force Derived From Load Cell Test Data as a Function of Specimen Height Divided by Thickness for Impact Specimens With a TWENTY-Degree Angle of Inclination.

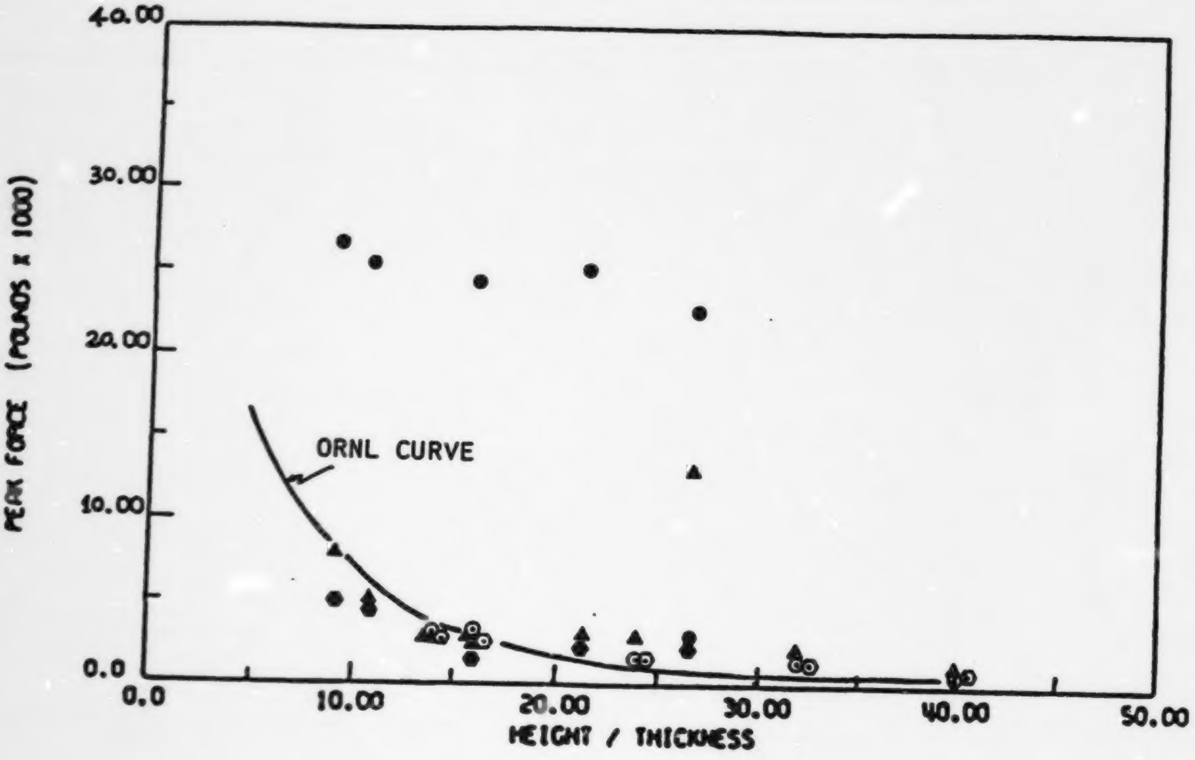


FIGURE 26

The Peak Force Derived From Load Cell Test Data as a Function of Specimen Height Divided by Thickness for Impact Specimens With a THIRTY-Degree Angle of Inclination.

WIDE SINGLE FIN   0.250 inches THICK,   3.5 inches HIGH,   10.0 inches WIDE,   0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
12301	90.25	565	50991	50493.	23913.	27031.	19.1	20.6	8.107	8.187	3.840
12302	90.25	565	50991.	50525.	37377.	27031.	21.4	23.2	8.113	8.187	6.001
12303	90.25	565	50991.	50544.	32051.	27171.	22.6	25.6	8.116	8.187	5.146
12304	90.25	565	50991.	50393.	26263.	27879.	16.9	14.9	8.091	8.187	4.217
12305	90.25	565	50991	50396.	28945.	27970.	16.9	15.1	8.092	8.187	4.648

WIDE SINGLE FIN: 0.250 inches THICK,   3.5 inches HIGH,   10.0 inches WIDE,   10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
12311	90.25	565	50991	50226.	21388.	39941.	37.3	46.0	8.065	8.187	3.434
12312	90.25	565.	50991	50220	27347.	29248.	73.7	78.8	8.064	8.187	4.391
12313	90.25	485	43771	42906.	24615.	22938.	48.6	60.5	6.889	7.028	3.952
12314	90.25	485	43771	42951.	21828.	40036.	48.6	58.4	6.896	7.028	3.505
12315	90.25	485	43771	42881.	22841.	22248.	36.2	42.8	6.385	7.028	3.667

WIDE SINGLE FIN: 0.250 inches THICK,   3.5 inches HIGH,   10.0 inches WIDE,   20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
12321	90.25	325.	29331	29058.	21214.	3797.	70.1	76.5	4.666	4.710	3.406
12322	90.25	245.	22111.	21927.	11156.	3469.	42.8	52.9	3.521	3.550	1.791
12323	90.25	245.	22111.	21913.	13406.	3621.	36.8	45.9	3.518	3.550	2.153
12324	90.25	245	22111	22011.	14539.	4038.	29.5	37.9	3.534	3.550	2.334
12325	90.25	245	22111	21783.	16079.	4852.	23.7	33.3	3.498	3.550	2.582

WIDE SINGLE FIN: 0.250 inches THICK,   3.5 inches HIGH,   10.0 inches WIDE,   30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
12331	90.25	205.	18501.	18327.	12854.	2649.	68.9	76.2	2.943	2.971	2.064
12332	90.25	165.	14891	14784.	12324.	2894.	48.2	62.4	2.374	2.391	1.979
12333	90.25	165	14891.	14785	464.	3897.	44.2	64.4	2.374	2.391	0.074
12334	90.25	165	14891	14780.	8593.	2082.	45.6	60.0	2.373	2.391	1.380
12335	90.25	165	14891	14779	11100.	3471.	48.2	60.7	2.373	2.391	1.782

WIDE SINGLE FIN: 0.250 inches THICK, 4.0 inches HIGH, 10.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
12401	90.25	565.	50991.	49886.	27456.	25987.	32.3	20.6	8.010	8.187	4.408
12402	90.25	565.	50991.	49884.	22031.	27191.	23.3	25.7	8.010	8.187	3.537
12403	90.25	565.	50991.	49825.	25682.	27459.	21.5	23.1	8.000	8.187	4.124
12404	90.25	565.	50991.	49661.	33143.	28386.	18.5	17.2	7.974	8.187	5.322
12405	90.25	565.	50991.	50406.	34200.	26826.	14.5	14.0	8.094	8.187	5.491

WIDE SINGLE FIN: 0.250 inches THICK, 4.0 inches HIGH, 10.0 inches WIDE, 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
12411	90.25	485.	43771.	43028.	19819.	19165.	46.2	53.8	6.909	7.028	3.182
12412	90.25	485.	43771.	42908.	12104.	22278.	45.2	53.9	6.889	7.028	1.943
12413	90.25	485.	43771.	42721.	19923.	40937.	27.1	20.4	6.859	7.028	3.199
12414	90.25	485.	43771.	42856.	23192.	23029.	31.2	33.9	6.881	7.028	3.724
12415	90.25	485.	43771.	42841.	13561.	24039.	27.1	34.0	6.879	7.028	2.177

WIDE SINGLE FIN: 0.250 inches THICK, 4.0 inches HIGH, 10.0 inches WIDE, 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
12421	90.25	205.	18501.	18312.	7428.	4553.	33.2	36.8	2.940	2.971	1.193
12422	90.25	245.	22111.	21924.	9469.	3306.	38.3	49.3	3.520	3.550	1.520
12423	90.25	205.	18501.	18291.	7923.	3306.	36.1	35.8	2.937	2.971	1.272
12424	90.25	245.	22111.	21942.	6302.	3043.	44.7	46.4	3.523	3.550	1.012
12425	90.25	245.	22111.	21946.	14439.	3157.	40.4	49.3	3.524	3.550	2.318

WIDE SINGLE FIN: 0.250 inches THICK, 4.0 inches HIGH, 10.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
12431	90.25	325.	29331.	29120.	26033.	8869.	78.4	83.3	4.676	4.710	4.180
12432	90.25	165.	14891.	14761.	1635.	1882.	51.2	63.1	2.370	2.391	0.262
12433	90.25	165.	14891.	14801.	10067.	1815.	48.9	62.0	2.377	2.391	1.616
12434	90.25	165.	14891.	14795.	6379.	2216.	45.7	58.6	2.376	2.391	1.024
12435	90.25	165.	14891.	14801.	11738.	1914.	51.2	65.0	2.377	2.391	1.885

WIDE SINGLE FIN 0.250 inches THICK. 6.0 inches HIGH. 10.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
12601	90.25	565	50991	50041.	14302	25396.	37.2	39.1	8.035	8.187	2.296
12602	90.25	565	50991.	50043.	30984	25808.	36.5	41.2	8.035	8.187	4.975
12603	90.25	565	50991	49666	28491.	29260.	27.8	15.2	7.975	8.187	4.575
12604	90.25	565	50991	49895.	24034.	26923.	35.2	20.3	8.011	8.187	3.859
12605	90.25	565	50991	50010.	36083.	25605.	35.8	38.8	8.030	8.187	5.794

WIDE SINGLE FIN. 0.250 inches THICK. 6.0 inches HIGH. 10.0 inches WIDE. 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
12611	90.25	485.	43771	42805.	27900.	22497	82.1	91.3	6.873	7.028	4.480
12612	90.25	405.	36551	34673.	25085.	22106.	72.1	75.3	5.567	5.869	4.028
12613	90.25	405.	36551	26751.	16666.	20484.	77.5	47.4	4.295	5.869	2.676
12614	90.25	405.	36551	27834.	20377.	22457.	72.1	46.0	4.469	5.869	3.272
12615	90.25	405.	36551	31938.	16530.	21338.	40.8	38.8	5.128	5.869	2.654

WIDE SINGLE FIN: 0.250 inches THICK. 6.0 inches HIGH. 10.0 inches WIDE. 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
12621	90.25	365	32941.	32533	0.	4885.	84.6	88.8	5.224	5.289	0.000
12622	90.25	245.	22111.	15128.	0.	3220.	79.8	60.1	2.429	3.550	0.000
12623	- - -	- - -	- - -	NO TRACE	- - -	- - -	- - -	- - -	- - -	- - -	- - -
12624	90.25	165.	14891.	14763.	0.	3523.	33.7	41.5	2.370	2.391	0.000
12625	90.25	165.	14891.	14752.	0.	3329.	22.0	31.4	2.369	2.391	0.000

WIDE SINGLE FIN: 0.250 inches THICK. 6.0 inches HIGH. 10.0 inches WIDE. 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
12631	22.50	405.	9113.	8879.	0.	3003.	6.9	14.9	1.426	1.463	0.000
12632	22.50	405	9113.	9080.	0.	1847.	38.8	43.6	1.458	1.463	0.000
12633	22.50	405	9113	2900.	0.	18051	38.8	1.9	0.466	1.463	0.000
12634	22.50	405	9113.	9086.	5076	1160.	46.3	54.6	1.459	1.463	0.815
12635	22.50	405	9113	5343	0	796	47.8	90.0	0.858	1.463	0.000

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WIDE SINGLE FIN:   0.250 inches THICK.   8.0 inches HIGH.   10.0 inches WIDE.   0.0 degrees INCLINATION
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 FIN ID : DROP   : HAMMER : IMPACT : PEAK ENERGY ABSORBED  : PEAK FORCE PER : PERCENT DEFORMATION :   (PEAK ENERGY ABS)/         :
 NUMBER : HEIGHT : WEIGHT : ENERGY :   BY FIN  (in-lbs)    : UNIT FIN WIDTH :        ( % )        :   (PLASTIC MOMENT)           :
        :        :        :        :  FROM    :   FROM     :                :           :  FROM   :                              :
        : (ins)  : (lbs)  : (in-lb): LOADCELL : ACCELRMTR  :   (lbs/in)     : MEASURED  : LOADCELL: LOADCELL:THEORY: ACCELRMTR:
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: 12801 : 90.25  :  365.  : 50991  :  50170   :  20399.    :    20451.      :   29.8    :   21.1  :  8.056 : 8.187:  3.274   :
: 12802 : 90.25  :  365.  : 50991. :  50017   :  22577.    :    25534.      :   27.2    :   26.4  :  8.031 : 8.187:  3.625   :
: 12803 : 90.25  :  365.  : 50991  :  50156   :  29844     :    24027.      :   30.1    :   31.2  :  8.053 : 8.187:  4.792   :
: 12804 : 90.25  :  365.  : 50991  :  50038   :  37633.    :    24703.      :   27.2    :   29.3  :  8.034 : 8.187:  6.042   :
: 12805 : 90.25  :  365   : 50991. :  49995   :  35161     :    26937.      :   25.8    :   29.9  :  8.028 : 8.187:  5.646   :
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WIDE SINGLE FIN:   0.250 inches THICK.   8.0 inches HIGH.   10.0 inches WIDE.   10.0 degrees INCLINATION
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 FIN ID : DROP   : HAMMER : IMPACT : PEAK ENERGY ABSORBED  : PEAK FORCE PER : PERCENT DEFORMATION :   (PEAK ENERGY ABS)/         :
 NUMBER : HEIGHT : WEIGHT : ENERGY :   BY FIN  (in-lbs)    : UNIT FIN WIDTH :        ( % )        :   (PLASTIC MOMENT)           :
        :        :        :        :  FROM    :   FROM     :                :           :  FROM   :                              :
        : (ins)  : (lbs)  : (in-lb): LOADCELL : ACCELRMTR  :   (lbs/in)     : MEASURED  : LOADCELL: LOADCELL:THEORY: ACCELRMTR:
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: 12811 : 90.25  :  405.  : 36551  :  35450.  :   9428.    :    18629.      :    8.6    :   14.4  :  5.692 : 5.869:  1.514   :
: 12812 : 90.25  :  445.  : 40161  :  36197   :  24501     :    15155.      :   15.6    :   65.4  :  5.812 : 6.448:  3.934   :
: 12813 : 90.25  :  445.  : 40161  :  36656.  :   4888     :    18948       :   69.0    :   69.8  :  5.886 : 6.448:  0.785   :
: 12814 : 90.25  :  445.  : 40161  :  33792   :  15977     :    18625.      :   83.1    :   78.6  :  5.426 : 6.448:  2.565   :
: 12815 : 90.25  :  445.  : 40161. :  32211.  :  16251.    :    18691.      :   81.6    :   69.6  :  5.172 : 6.448:  2.609   :
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WIDE SINGLE FIN:   0.250 inches THICK.   8.0 inches HIGH.   10.0 inches WIDE.   20.0 degrees INCLINATION
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 FIN ID : DROP   : HAMMER : IMPACT : PEAK ENERGY ABSORBED  : PEAK FORCE PER : PERCENT DEFORMATION :   (PEAK ENERGY ABS)/         :
 NUMBER : HEIGHT : WEIGHT : ENERGY :   BY FIN  (in-lbs)    : UNIT FIN WIDTH :        ( % )        :   (PLASTIC MOMENT)           :
        :        :        :        :  FROM    :   FROM     :                :           :  FROM   :                              :
        : (ins)  : (lbs)  : (in-lb): LOADCELL : ACCELRMTR  :   (lbs/in)     : MEASURED  : LOADCELL: LOADCELL:THEORY: ACCELRMTR:
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: 12821 : 22.50  :  405.  :  9113. :   8829.  :     0.     :     4061.      :   34.0    :   31.9  :  1.418 : 1.463:  0.000   :
: 12822 : 22.50  :  405.  :  9113. :   8986.  :     0.     :     2014.      :   41.9    :   39.0  :  1.443 : 1.463:  0.000   :
: 12823 : 22.50  :  405.  :  9113  :   8963.  :     0.     :     2409.      :   38.3    :   37.0  :  1.439 : 1.463:  0.000   :
: 12824 : 22.50  :  405.  :  9113. :   8979   :     0.     :     1927.      :   41.9    :   38.6  :  1.442 : 1.463:  0.000   :
: 12825 : 22.50  :  405.  :  9113. :   8918.  :     0.     :     2852.      :   36.7    :   34.8  :  1.432 : 1.463:  0.000   :
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WIDE SINGLE FIN:   0.250 inches THICK.   8.0 inches HIGH.   10.0 inches WIDE.   30.0 degrees INCLINATION
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 FIN ID : DROP   : HAMMER : IMPACT : PEAK ENERGY ABSORBED  : PEAK FORCE PER : PERCENT DEFORMATION :   (PEAK ENERGY ABS)/         :
 NUMBER : HEIGHT : WEIGHT : ENERGY :   BY FIN  (in-lbs)    : UNIT FIN WIDTH :        ( % )        :   (PLASTIC MOMENT)           :
        :        :        :        :  FROM    :   FROM     :                :           :  FROM   :                              :
        : (ins)  : (lbs)  : (in-lb): LOADCELL : ACCELRMTR  :   (lbs/in)     : MEASURED  : LOADCELL: LOADCELL:THEORY: ACCELRMTR:
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: 12831 : 22.50  :  325.  :  7313. :   7045.  :     0.     :     1515.      :   43.9    :   42.4  :  1.131 : 1.174:  0.000   :
: 12832 : 22.50  :  325.  :  7313. :   7257.  :  1611.     :     1518.      :   44.4    :   44.6  :  1.165 : 1.174:  0.259   :
: 12833 - - - - - - - - - - - - - - - NO TRACE - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - :
: 12834 : 22.50  :  325   :  7313  :   7283   :  2325      :      693.      :   50.6    :   48.7  :  1.169 : 1.174:  0.373   :
: 12835 - - - - - - - - - - - - - - - NO TRACE - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - :
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WIDE SINGLE FIN 0.250 inches THICK. 10.0 inches HIGH. 10.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
12101	90.25	445	40161	39174.	27679.	18952.	17.0	21.4	6.290	6.448	4.444
12102	90.25	485	43771	42784.	22972.	18669.	96.3	20.8	6.870	7.028	3.689
12103	90.25	485.	43771	42599.	29205.	18935.	8.3	11.5	6.840	7.028	4.689
12104	90.25	485.	43771	42767.	23736.	18581.	16.6	19.8	6.867	7.028	3.811
12105	90.25	485	43771	42862.	14718.	19042.	21.7	23.8	6.882	7.028	2.363

WIDE SINGLE FIN 0.250 inches THICK. 10.0 inches HIGH. 10.0 inches WIDE. 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
12111	90.25	245.	22111	20832.	0.	9719.	0.5	13.5	3.345	3.550	0.000
12112	90.25	325.	29331.	22907.	19533.	9725.	73.3	71.2	3.678	4.710	3.136
12113	90.25	325.	29331.	28896.	15453.	12236.	58.9	18.3	4.640	4.710	2.481
12114	90.25	325	29331	27995.	19953.	18624.	17.6	26.8	4.495	4.710	3.204
12115	90.25	325.	29331.	25319.	20474.	19054.	33.7	19.8	4.065	4.710	3.287

WIDE SINGLE FIN 0.250 inches THICK. 10.0 inches HIGH. 10.0 inches WIDE. 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
12121	22.50	325	7313	7221.	0.	1487.	34.2	33.3	1.159	1.174	0.000
12122	22.50	325	7313	7201.	0.	1489.	28.0	29.6	1.156	1.174	0.000
12123	22.50	325.	7313	7206.	0.	1490.	32.6	32.5	1.157	1.174	0.000
12124	22.50	325.	7313	7183.	0.	1986.	26.4	27.5	1.153	1.174	0.000
12125	22.50	325.	7313	7213.	0.	1804.	33.5	32.6	1.158	1.174	0.000

WIDE SINGLE FIN 0.250 inches THICK. 10.0 inches HIGH. 10.0 inches WIDE. 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
12131	12.00	485.	5820	5748.	440.	394.	48.7	45.6	0.923	0.934	0.071
12132	12.00	485	5820	5739.	1190.	654.	54.2	39.7	0.921	0.934	0.191
12133	12.00	485	5620	5742.	1588	532	56.8	43.0	0.922	0.934	0.255
12134	12.00	485	5620.	5730.	534.	491.	45.5	35.7	0.920	0.934	0.086
12135	12.00	485	5820	0.	4653.	0.	55.1	0.0	0.000	0.934	0.747

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WIDE SINGLE FIN 0.375 inches THICK. 3.5 inches HIGH. 10.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
13301	204.00	565.	115260.	113671.	69751.	46382.	14.6	16.1	7.814	7.923	4.795
13302	204.00	565.	115260.	113551.	38577.	42167.	13.4	15.3	7.806	7.923	2.652
13303	204.00	565	115260	113383.	31015.	43818.	14.6	13.8	7.794	7.923	2.132
13304	204.00	565.	115260.	113695	90104.	41258.	14.6	16.4	7.816	7.923	6.194
13305	204.00	565.	115260.	113526.	74356.	42576.	13.4	15.1	7.804	7.923	5.111

WIDE SINGLE FIN 0.375 inches THICK. 3.5 inches HIGH. 10.0 inches WIDE. 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
13311	204.00	565.	115260	112906.	0.	33152.	70.4	73.6	7.761	7.923	0.000
13312	204.00	485.	98940	96926.	36960.	39389.	59.1	69.0	6.664	6.801	2.541
13313	204.00	485.	98940.	96881.	55233.	35429.	66.9	69.6	6.660	6.801	3.797
13314	204.00	485.	98940.	97995.	68673.	35481.	49.8	54.4	6.736	6.801	4.721
13315	204.00	485	98940	97941	32908.	36337.	59.1	34.1	6.733	6.801	2.262

WIDE SINGLE FIN 0.375 inches THICK. 3.5 inches HIGH. 10.0 inches WIDE. 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
13331	- - - -	- - - -	- - - -	NO TRACE	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
13332	90.25	365.	32941.	32808.	24447.	5736.	30.1	42.5	2.255	2.264	1.681
13333	90.25	365.	32941.	32621.	23673.	6385.	14.6	48.1	2.242	2.264	1.627
13334	90.25	365	32941.	32609.	1877.	8154.	32.7	49.3	2.242	2.264	0.129
13335	90.25	365.	32941.	32633.	19878.	5065.	34.0	51.5	2.243	2.264	1.366

WIDE SINGLE FIN 0.375 inches THICK. 4.0 inches HIGH. 10.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
13401	204.00	565	115260.	113643.	87963.	45769.	13.5	14.6	7.812	7.923	6.047
13402	204.00	565	115260	113554.	52891.	46019.	15.5	13.5	7.806	7.923	3.636
13403	204.00	565	115260.	113627.	46901.	57335	15.5	14.3	7.811	7.923	3.224
13404	204.00	565	115260.	113750.	55398.	43754.	14.5	16.1	7.819	7.923	3.808
13405	204.00	565	115260	113726.	88636.	44410	14.5	15.8	7.818	7.923	6.093

WIDE SINGLE FIN: 0.375 inches THICK, 4.0 inches HIGH, 10.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
13431	90.25	325	29331.	28991.	16298.	5232.	57.0	72.1	1.993	2.016	1.120
13432	90.25	325	29331.	29144.	23188.	8264.	51.2	64.0	2.003	2.016	1.594
13433	90.25	325	29331.	29102.	23497.	5171.	40.0	47.4	2.001	2.016	1.615
13434	90.25	325	29331.	29043.	18653.	8181.	37.6	38.2	1.996	2.016	1.282
13435	90.25	325.	29331.	29206.	24310.	4939.	21.8	34.3	2.008	2.016	1.685

WIDE SINGLE FIN: 0.375 inches THICK, 6.0 inches HIGH, 10.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
13601	204.00	565.	115260.	114057.	71372.	63314.	18.7	19.1	7.841	7.923	4.906
13602	204.00	565.	115260.	114070.	72093.	45309.	20.0	19.5	7.841	7.923	4.956
13603	204.00	565.	115260.	113879.	86980.	46601.	20.0	14.0	7.828	7.923	5.979
13604	204.00	565	115260	114113.	47285.	44015.	20.7	20.5	7.844	7.923	3.250
13605	204.00	565.	115260.	113955.	38106.	46688.	16.2	17.6	7.834	7.923	2.620

WIDE SINGLE FIN: 0.375 inches THICK, 6.0 inches HIGH, 10.0 inches WIDE, 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
13611	204.00	565	115260	110482.	0.	58759.	80.7	85.2	7.595	7.923	0.000
13612				NO TRACE							
13613				NO TRACE							
13614				NO TRACE							
13615				NO TRACE							

WIDE SINGLE FIN: 0.375 inches THICK, 6.0 inches HIGH, 10.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
13631	90.25	325	29331	26692.	21260.	6125.	60.0	146.6	1.835	2.016	1.461
13632	90.25	325.	29331.	28781.	11120.	3942.	58.4	96.9	1.978	2.016	0.764
13633	90.25	325.	29331	29139	16200.	3573.	58.4	80.1	2.003	2.016	1.114
13634	90.25	325.	29331	29071.	4371.	3405.	55.4	83.4	1.998	2.016	0.300
13635	90.25	325	29331	29039.	11607	3117.	54.6	81.2	1.996	2.016	0.798

WIDE SINGLE FIN 0.375 inches THICK, 8.0 inches HIGH, 10.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
13801	204.00	565.	115260.	112460.	75969.	44711.	20.9	19.3	7.731	7.923	5.222
13802	NO TRACE										
13803	204.00	565	115260	112344.	55872.	45682.	21.9	25.1	7.737	7.923	3.841
13804	204.00	565	115260.	111231	21348	46963.	7.5	6.9	7.646	7.923	1.468
13805	204.00	565.	115260.	112684.	63304.	42999.	19.4	21.1	7.746	7.923	4.352

WIDE SINGLE FIN 0.375 inches THICK, 8.0 inches HIGH, 10.0 inches WIDE, 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
13821	90.25	485.	43771.	43506	9788.	23103.	99.9	45.9	2.991	3.009	0.673
13822	90.25	565.	50991.	50612.	19816.	29202.	22.0	34.4	3.479	3.505	1.362
13823	NO TRACE										
13824	NO TRACE										
13825	NO TRACE										

WIDE SINGLE FIN 0.375 inches THICK, 9.0 inches HIGH, 10.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
13831	90.25	365.	32941.	32668.	21496.	4392.	79.6	69.8	2.246	2.264	1.478
13832	90.25	325.	29331.	25956.	12483.	4555.	64.8	104.1	1.784	2.016	0.858
13833	90.25	325.	29331.	29143.	20677.	5450	73.3	75.5	2.003	2.016	1.421
13834	90.25	325.	29331.	28693	7217.	2460.	72.9	107.9	1.972	2.016	0.496
13835	90.25	325	29331.	26692.	21260.	6125.	60.9	110.0	1.835	2.016	1.461

WIDE SINGLE FIN 0.375 inches THICK, 10.0 inches HIGH, 10.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
13101	203.00	565.	114695.	109978.	28904.	42335.	20.5	22.9	7.560	7.884	1.987
13102	203.00	565.	114695.	112449.	59019.	40737.	24.1	25.0	7.730	7.884	4.057
13103	203.00	565	114695	112291.	52576.	42791.	22.9	26.5	7.719	7.884	3.614
13104	203.00	565	114695	112342.	35732.	42739.	22.5	26.2	7.723	7.884	2.456
13105	203.00	565	114695	112346.	36294.	41939.	21.3	23.4	7.723	7.884	2.495

WIDE SINGLE FIN 0.375 inches THICK. 10.0 inches HIGH. 10.0 inches WIDE. 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
13111	204.00	565	115260.	113086	20984.	34827.	86.1	91.6	7.774	7.923	1.442
13112	204.00	485.	98940	91605.	50905.	53126.	81.2	98.3	6.297	6.801	3.499
13113	204.00	405	82620	75486	34146.	32607	64.5	72.6	5.189	5.680	2.347
13114	204.00	405.	82620	79673.	8689.	34571.	42.1	13.1	5.477	5.680	0.597
13115	204.00	405	82620.	78586.	31218.	45383.	20.1	10.8	5.402	5.680	2.146

WIDE SINGLE FIN 0.375 inches THICK. 10.0 inches HIGH. 10.0 inches WIDE. 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
13121	90.25	325.	29331.	28072.	20547.	5541.	13.7	36.5	1.930	2.016	1.412
13122	90.25	405.	36551.	35915.	21854.	6683	33.1	65.0	2.469	2.513	1.502
13123	90.25	405.	36551	35967.	14416.	5797.	21.7	41.9	2.472	2.513	0.991
13124	90.25	485.	43771.	42486.	21315.	7544.	24.7	46.2	2.921	3.009	1.465
13125	90.25	485.	43771	43369.	31444.	9011.	7.0	22.1	2.981	3.009	2.162

WIDE SINGLE FIN 0.375 inches THICK. 10.0 inches HIGH. 10.0 inches WIDE. 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
13131	90.25	165.	14891	12969.	10626.	1774.	26.0	63.7	0.892	1.024	0.730
13132	90.25	285	25721.	25524.	16069.	4158	71.8	49.3	1.755	1.768	1.105
13133	90.25	285.	25721.	23060.	13639.	1895.	72.3	128.3	1.585	1.768	0.938
13134	90.25	285	25721	25609	19675.	1962.	70.1	103.0	1.760	1.768	1.353
13135	90.25	285	25721	25603.	12640.	3014.	71.0	86.1	1.760	1.768	0.869

DOUBLE PARALLEL FINS: 0.250 inches THICK. 3.5 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
22301	90.25	340	30685	30529.	18362.	51451.	46.3	46.2	12.261	12.323	7.374
22302	90.25	340.	30685.	30520.	19847.	54662	45.1	45.5	12.257	12.323	7.971
22303	90.25	340	30685	30522.	6112.	54752	44.0	43.8	12.258	12.323	2.454
22304	90.25	340	30685.	30506.	11362.	54630.	36.0	36.8	12.251	12.323	4.563
22305	90.25	340.	30685.	30532.	21459.	50941.	46.3	46.2	12.262	12.323	8.618

DOUBLE PARALLEL FINS: 0.250 inches THICK. 3.5 inches HIGH. 2.0 inches WIDE. 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
22311	90.25	340.	30685.	30400.	8122.	46544.	61.4	59.7	12.209	12.323	3.262
22312	90.25	340.	30685.	30397.	4788.	47538.	61.4	59.8	12.208	12.323	1.923
22313	90.25	340.	30685.	30393.	12732.	48061.	56.8	57.6	12.206	12.323	5.113
22314	90.25	340.	30685	30238.	22685.	43740.	84.0	68.7	12.144	12.323	9.111
22315	90.25	340.	30685	30380.	8369.	47105.	74.9	75.3	12.201	12.323	3.361

DOUBLE PARALLEL FINS: 0.250 inches THICK. 3.5 inches HIGH. 2.0 inches WIDE. 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
22321	22.50	340.	7650.	7601.	0.	7560.	30.7	31.9	3.033	3.072	0.000
22322	22.50	340.	7650.	0.	3200.	34.	21.3	0.0	0.000	3.072	1.285
22323	22.50	340.	7650.	7576.	0.	8283.	18.8	22.6	3.043	3.072	0.000
22324	22.50	340	7650.	0.	0.	0.	12.7	0.0	0.000	3.072	0.000
22325				NO TRACE							

DOUBLE PARALLEL FINS: 0.250 inches THICK. 3.5 inches HIGH. 2.0 inches WIDE. 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
22331	22.50	220.	4950.	4902.	4388.	5715.	18.2	24.1	1.969	1.988	1.842
22332	22.50	260.	5850.	5803.	1921	6469.	26.1	27.8	2.331	2.349	0.772
22333	22.50	260.	5850.	0.	1381.	19.	30.1	0.0	0.000	2.349	0.555
22334	22.50	260.	5850	5809.	0.	5382.	27.4	30.1	2.333	2.349	0.000
22335	22 50	260	5850	5804	2067	5854.	23.5	27.2	2.331	2.349	0.830

DOUBLE PARALLEL FINS. 0.250 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT	HAMMER WEIGHT	IMPACT ENERGY	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
	(ins)	(lbs)	(in-lb)	FROM LOADCELL	FROM ACCELRMTR	(lbs/in)	MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
22401	90.25	340	30685.	30339.	4691.	52345.	49.0	49.0	12.184	12.323	1.884
22402	90.25	340.	30685.	30327.	17435.	52982.	48.0	47.6	12.179	12.323	7.002
22403	90.25	340.	30685	30282.	1161.	51319.	44.0	43.5	12.162	12.323	0.466
22404	90.25	340	30685.	30320.	15366.	53433	46.0	46.0	12.177	12.323	6.171
22405	90.25	340	30685.	30232.	16302.	58259.	46.0	32.6	12.141	12.323	6.547

DOUBLE PARALLEL FINS. 0.250 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT	HAMMER WEIGHT	IMPACT ENERGY	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
	(ins)	(lbs)	(in-lb)	FROM LOADCELL	FROM ACCELRMTR	(lbs/in)	MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
22411	90.25	260.	23465.	22857.	4527.	47100.	52.3	53.3	9.180	9.424	1.818
22412	90.25	260.	23465.	23053.	15614.	52473.	53.0	29.2	9.258	9.424	6.271
22413	90.25	260.	23465.	23052.	15839.	41122.	82.0	86.5	9.258	9.424	6.361
22414	90.25	260.	23465.	23121.	10387.	44285.	55.1	32.1	9.286	9.424	4.171
22415	90.25	260.	23465.	23117.	13779.	43268.	82.0	84.2	9.284	9.424	5.534

DOUBLE PARALLEL FINS: 0.250 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT	HAMMER WEIGHT	IMPACT ENERGY	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
	(ins)	(lbs)	(in-lb)	FROM LOADCELL	FROM ACCELRMTR	(lbs/in)	MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
22421	22.50	300.	6750.	6697.	0.	7345.	19.4	23.5	2.690	2.711	0.000
22422	22.50	380.	8550.	8479.	0.	7500.	16.5	21.6	3.405	3.434	0.000
22423	2.50	380.	950.	913.	0.	13351.	14.3	2.0	0.367	0.382	0.000
22424	90.25	100.	9025.	8947.	6068.	7617.	43.6	50.5	3.593	3.624	2.437
22425	90.25	100	9025.	8926.	6374.	8012.	27.9	34.1	3.585	3.624	2.560

DOUBLE PARALLEL FINS: 0.250 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT	HAMMER WEIGHT	IMPACT ENERGY	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
	(ins)	(lbs)	(in-lb)	FROM LOADCELL	FROM ACCELRMTR	(lbs/in)	MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
22431	90.25	100	9025	8983.	0.	6089.	73.9	89.7	3.608	3.624	0.000
22432	22.50	300	6750.	4375.	0.	3600.	60.5	53.8	1.757	2.711	0.000
22433	22.50	300	6750	6727	0.	4161.	61.6	56.6	2.702	2.711	0.000
22434	22.50	300	6750.	6724	0.	4947.	54.7	51.1	2.700	2.711	0.000
22435	22.50	300	6750	6725.	0.	4208.	60.5	59.3	2.701	2.711	0.000

DOUBLE PARALLEL FINS 0.250 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
22601	90.25	340.	30685.	30346.	16245.	53409.	49.5	47.5	12.187	12.323	6.524
22602	90.25	340.	30685.	30362.	5133.	51164.	52.8	52.9	12.193	12.323	2.062
22603	90.25	340.	30685.	30333.	5166.	51899.	52.2	50.7	12.182	12.323	2.075
22604	90.25	340.	30685.	30313.	12169.	53522.	51.5	47.8	12.174	12.323	4.887
22605	90.25	340.	30685.	30374.	20070.	46449.	49.5	49.0	12.198	12.323	8.060

DOUBLE PARALLEL FINS 0.250 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
22611	90.25	220.	19855.	19057.	1781.	43891.	86.7	88.2	7.653	7.974	0.715
22612	90.25	140.	12635.	12210.	5071.	43863.	17.4	19.6	4.904	5.074	2.037
22613				NO TRACE							
22614				NO TRACE							
22615	90.25	140.	12635.	12252.	3669.	32999.	61.4	66.1	4.921	5.074	1.474

DOUBLE PARALLEL FINS: 0.250 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
22621	90.25	100.	9025.	8855.	0.	11969.	15.6	17.2	3.556	3.624	0.000
22622	90.25	180.	16245.	13099.	0.	13018.	82.5	53.6	5.261	6.524	0.000
22623	90.25	140.	12635.	11023.	0.	13289.	72.9	50.4	4.427	5.074	0.000
22624	90.25	140.	12635.	10881.	0.	12457.	75.7	51.9	4.370	5.074	0.000
22625	90.25	140	12635.	10470.	0.	11490.	77.8	54.8	4.205	5.074	0.000

DOUBLE PARALLEL FINS: 0.250 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
22631	90.25	100.	9025.	8142.	0.	5472.	58.4	52.8	3.270	3.624	0.000
22632	90.25	100.	9025.	7850.	0.	8287.	65.9	56.7	3.153	3.624	0.000
22633	90.25	100.	9025.	7643.	0.	5454.	74.4	59.5	3.069	3.624	0.000
22634	90.25	100.	9025.	7669.	0.	4881.	68.2	59.7	3.080	3.624	0.000
22635	90.25	100	9025.	7219.	0.	5992.	76.5	64.0	2.899	3.624	0.000

DOUBLE PARALLEL FINS. 0.250 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
22801	90.25	260	23465.	23135.	14138.	51382.	40.5	38.2	9.291	9.424	5.678
22802	90.25	260	23465	23117.	8320.	52028.	40.0	41.8	9.284	9.424	3.341
22803	90.25	260	23465.	23070.	17742.	51253.	34.6	16.5	9.265	9.424	7.125
22804	90.25	260	23465.	23120.	12226.	53509.	41.0	40.1	9.285	9.424	4.910
22805	90.25	260.	23465	22811.	667.	51884.	40.0	39.2	9.161	9.424	0.268

DOUBLE PARALLEL FINS: 0.250 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
22811	90.25	260.	23465.	22530.	17419.	28604.	80.1	75.3	9.048	9.424	6.996
22812	90.25	260.	23465.	22975.	5605.	28414.	77.5	72.6	9.227	9.424	2.251
22813	90.25	260.	23465.	23265.	16188	28566.	83.6	82.3	9.343	9.424	6.501
22814	90.25	260.	23465	23264.	6661.	29086.	85.0	83.5	9.343	9.424	2.675
22815	90.25	220.	19855	19522.	9425.	28317.	75.1	72.5	7.840	7.974	3.785

DOUBLE PARALLEL FINS: 0.250 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
22821	22.50	300.	6750.	6667.	0.	12721.	11.0	11.3	2.677	2.711	0.000
22822	22.50	380.	8550.	8492.	0.	10928.	24.2	19.1	3.410	3.434	0.000
22823	22.50	460.	10350.	9684.	0.	13072.	72.3	38.1	3.889	4.157	0.000
22824	22.50	460.	10350.	9161.	0.	9932.	83.4	44.9	3.679	4.157	0.000
22825	22.50	460.	10350.	10287.	0.	11319.	32.0	21.9	4.131	4.157	0.000

DOUBLE PARALLEL FINS: 0.250 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
22831	22.50	220.	4950	4764	0	5166.	61.5	42.6	1.913	1.980	0.000
22832	22.50	220.	4950	4656	1321.	5091.	68.8	45.6	1.870	1.980	0.531
22833	22.50	220	4950	4919.	211.	3797.	44.4	33.3	1.975	1.980	0.085
22834	22.50	220	4950	4641	0.	4325.	70.0	47.6	1.864	1.980	0.000
22835	22.50	220	4950	4663.	0.	3920.	72.9	47.0	1.873	1.980	0.000

DOUBLE PARALLEL FINS: 0.250 inches THICK,   10.0 inches HIGH,   2.0 inches WIDE,   0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
22101				NO TRACE							
22102	180.00	120	21600	18382.	14966.	13293.	50.0	83.0	7.382	8.675	6.011
22103	180.00	120	21600.	1452.	16075.	12095.	31.5	10.4	0.583	8.675	6.456
22104				NO TRACE							
22105	240.00	180	43200	25020.	23262.	12955.	72.8	131.1	10.048	17.349	9.342

DOUBLE PARALLEL FINS: 0.250 inches THICK,   10.0 inches HIGH,   2.0 inches WIDE,   10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
22111				NO TRACE							
22112	90.25	180.	16245.	16062.	0.	14879.	22.1	32.0	6.450	6.524	0.000
22113	90.25	180.	16245.	15593.	0.	28769.	50.9	57.7	6.262	6.524	0.000
22114	90.25	180.	16245.	16074.	9636.	29124.	48.9	45.0	6.455	6.524	3.870
22115	90.25	180	16245.	15067.	3710.	28304.	78.1	65.7	6.051	6.524	1.490

DOUBLE PARALLEL FINS: 0.250 inches THICK,   10.0 inches HIGH,   2.0 inches WIDE,   20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
22121	22.50	300.	6750.	6657	2241.	14911.	10.4	8.7	2.673	2.711	0.900
22122	22.50	380.	8550	6747.	0.	14911.	87.4	40.5	2.710	3.434	0.000
22123	22.50	300	6750.	6675.	0.	11281.	10.8	10.8	2.681	2.711	0.000
22124	22.50	340	7650.	7584	0.	9500.	30.5	23.7	3.046	3.072	0.000
22125	22.50	340	7650	7604.	0.	8204.	31.8	20.8	3.054	3.072	0.000

DOUBLE PARALLEL FINS: 0.250 inches THICK,   10.0 inches HIGH,   2.0 inches WIDE,   30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
22131	22.50	180.	4050	4034.	1107.	3032.	77.4	58.2	1.620	1.627	0.444
22132	22.50	180	4050	2390.	0.	2646.	83.7	23.5	0.960	1.627	0.000
22133	22.50	180.	4050.	2349.	0.	2265.	83.7	24.0	0.943	1.627	0.000
22134	22.50	180	4050	0.	653.	1013.	83.3	0.0	0.000	1.627	0.262
22135	22.50	180	4050	2147.	0.	2626	84.6	24.7	0.862	1.627	0.000

DOUBLE PARALLEL FINS 0.375 inches THICK, 3.5 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
23301	90.25	565.	50991	47201.	11802.	66284.	16.9	18.5	8.113	8.764	2.028
23302	90.25	565	50991.	47356.	10867.	72540.	16.9	19.0	8.140	8.764	1.868
23303	90.25	563	50991	47352	23982	78646.	18.0	18.9	8.139	8.764	4.122
23304	90.25	565	50991.	47360.	7297.	78581.	19.1	18.7	8.140	8.764	1.254
23305	90.25	565	50991	46939.	13216.	80558.	18.0	16.8	8.068	8.764	2.272

DOUBLE PARALLEL FINS: 0.375 inches THICK, 3.5 inches HIGH, 2.0 inches WIDE, 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
23311	90.25	405.	36551	35589.	32930.	62895.	57.9	60.8	6.117	6.282	5.660
23312	90.25	405.	36551.	36391.	29762.	52807.	38.5	44.7	6.255	6.282	5.116
23313	90.25	405	36551.	35559.	24905.	65248.	54.5	60.0	6.112	6.282	4.281
23314	90.25	405.	36551	36380.	16905.	51655.	38.5	44.3	6.253	6.282	2.906
23315	90.25	405	36551.	36346.	30908.	58635.	32.7	38.0	6.247	6.282	5.312

DOUBLE PARALLEL FINS: 0.375 inches THICK, 3.5 inches HIGH, 2.0 inches WIDE, 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
23321	90.25	245.	22111.	21961.	20682.	15559.	45.0	58.4	3.775	3.800	3.555
23322	90.25	245.	22111	21959.	19047.	23432.	45.0	60.7	3.774	3.800	3.274
23323	90.25	245	22111	21885.	20356.	40511.	28.2	37.1	3.762	3.800	3.499
23324	90.25	245.	22111	21874.	20017.	24871.	29.5	36.1	3.760	3.800	3.441
23325	90.25	245.	22111.	21864.	19500.	22550.	25.8	36.0	3.758	3.800	3.352

DOUBLE PARALLEL FINS: 0.375 inches THICK, 3.5 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
23331	22.50	420	9450.	9255.	8788.	17594.	14.6	20.7	1.591	1.624	1.510
23332	22.50	420	9450	9358.	9244.	16411.	14.6	21.4	1.608	1.624	1.589
23333	22.50	420	9450	9407.	9109.	24338	13.2	20.6	1.617	1.624	1.566
23334	22.50	420	9450	9405	9306.	17223	14.6	19.9	1.617	1.624	1.599
23335	22.50	420	9450	9417	9112	10770.	17.2	24.3	1.619	1.624	1.566

DOUBLE PARALLEL FINS: 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
23401	90.25	485.	43771.	42927.	25372.	84251.	14.5	17.2	7.378	7.523	4.361
23402	90.25	485.	43771.	41257.	20484.	56958.	18.5	21.8	7.091	7.523	3.521
23403	90.25	485.	43771.	40777.	3302.	71988.	14.5	18.1	7.009	7.523	0.567
23404	90.25	485.	43771.	40597.	12841.	78837.	16.5	17.1	6.978	7.523	2.207
23405	90.25	485.	43771.	40979.	28801.	61862.	14.5	19.8	7.044	7.523	4.950

DOUBLE PARALLEL FINS: 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ARS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
23411	90.25	405.	36551.	35893.	29066.	86218.	19.3	21.9	6.169	6.282	4.996
23412	90.25	405.	36551.	33232.	28893.	71829.	68.3	63.1	5.712	6.282	4.966
23413	90.25	405.	36551.	35221.	33131.	59594.	56.1	54.6	6.054	6.282	5.695
23414	90.25	405.	36551	33038.	25292.	69351.	66.2	64.3	5.679	6.282	4.347
23415	90.25	405.	36551.	34059.	29831.	54897.	64.2	61.3	5.854	6.282	5.127

DOUBLE PARALLEL FINS: 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ARS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
23421	90.25	285.	25721.	25417.	23439.	27951.	74.9	81.2	4.369	4.421	4.029
23422	90.25	165.	14891.	14631.	9166.	22457.	13.3	19.6	2.515	2.560	1.575
23423	90.25	245.	22111.	21920.	20612.	23087.	51.8	39.8	3.768	3.800	3.543
23424	90.25	245.	22111.	21971.	21103.	19266.	50.0	59.8	3.776	3.800	3.627
23425	90.25	245.	22111.	21933.	15380.	23371.	56.1	42.1	3.770	3.800	2.643

DOUBLE PARALLEL FINS: 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ARS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
23431	90.25	100.	9025.	8775.	4347.	9635.	14.8	24.9	1.508	1.551	0.747
23432	22.50	380	8550.	8350.	7550.	13397.	9.4	15.3	1.435	1.470	1.298
23433	22.50	420	9450.	9275.	8550.	10583	13.7	20.1	1.594	1.624	1.470
23434	22.50	420	9450	9273	8476.	10822.	13.7	19.4	1.594	1.624	1.457
23435	22.50	420	9450	9280.	8103	9553.	13.7	20.5	1.595	1.624	1.393

DOUBLE PARALLEL FINS: 0.375 inches THICK. 6.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
23601	90.25	485	43771	43539	23487.	170687.	23.3	25.3	7.483	7.523	4.037
23602	90.25	485.	43771.	43301.	38165.	71830.	24.7	29.0	7.443	7.523	6.560
23603	90.25	485	43771	41956	30782.	78635.	34.5	36.6	7.211	7.523	5.291
23604	90.25	485	43771	43336	14399.	83223.	29.2	28.9	7.449	7.523	2.475
23605	90.25	485	43771.	42709.	27552.	81104.	31.8	31.8	7.341	7.523	4.736

DOUBLE PARALLEL FINS: 0.375 inches THICK. 6.0 inches HIGH. 2.0 inches WIDE. 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
23611	90.25	325.	29331.	28833.	15929.	66805.	37.4	45.7	4.956	5.041	2.738
23612	90.25	325.	29331	28829	15851.	66482.	26.7	30.0	4.955	5.041	2.725
23613	90.25	325.	29331.	28871	19213.	57467.	26.7	32.7	4.962	5.041	3.302
23614	90.25	325.	29331.	28973	19853.	59580.	32.8	47.7	4.980	5.041	3.412
23615	90.25	325	29331	28955.	18144.	101433	42.8	44.9	4.977	5.041	3.119

DOUBLE PARALLEL FINS: 0.375 inches THICK. 6.0 inches HIGH. 2.0 inches WIDE. 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
23621	90.25	260.	23465.	23369.	21191.	17074.	65.9	69.6	4.017	4.033	3.642
23622	90.25	280	25270	25170.	16000.	15875.	53.4	64.5	4.326	4.343	2.750
23623	90.25	280	25270.	25163	12063.	15013.	47.0	60.1	4.325	4.343	2.073
23624	90.25	280	25270	24995	0.	18550.	45.6	46.4	4.296	4.343	0.000
23625	90.25	280.	25270	25036.	13925.	20311.	47.0	58.4	4.303	4.343	2.393

DOUBLE PARALLEL FINS: 0.375 inches THICK. 6.0 inches HIGH. 2.0 inches WIDE. 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
23631	22.50	340	7650	7509	3228	10413.	26.7	30.8	1.291	1.315	0.555
23632	22.50	380	8550	8434	6680	6610.	35.5	39.4	1.450	1.470	1.148
23633	22.50	380	8550	8430	7940	6107.	34.2	36.4	1.449	1.470	1.365
23634	22.50	380	8550	8486	6554	6234	31.1	34.4	1.459	1.470	1.127
23635	90.25	100	9025	8877	6466	8937	20.5	32.3	1.526	1.551	1.111

DOUBLE PARALLEL FINS 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
23801	90.25	405	36551	36344	17203.	63293.	18.9	19.0	6.247	6.282	2.957
23802	90.25	405	36551	36274.	23656.	80758.	15.4	18.3	6.235	6.282	4.410
23803	90.25	405	36551	36275	25890	79499.	11.0	11.8	6.235	6.282	4.450
23804	90.25	405	36551	36313	23602.	87533.	14.9	16.6	6.241	6.282	4.057
23805	90.25	405	36551	36301.	23236	78587.	15.9	19.6	6.240	6.282	3.994

DOUBLE PARALLEL FINS 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 10.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
23811	90.25	325	29331.	29045.	2138.	41075.	38.1	37.2	4.992	5.041	0.368
23812	90.25	325	29331	27844.	16696.	72716.	83.6	106.5	4.786	5.041	2.870
23813	90.25	325	29331.	28602.	3137.	61787.	83.6	94.2	4.916	5.041	0.539
23814	90.25	325	29331	28676.	19491.	61281.	83.1	92.8	4.929	5.041	3.350
23815	90.25	325	29331.	28766.	12124	50532.	66.6	76.3	4.944	5.041	2.084

DOUBLE PARALLEL FINS: 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 20.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
23821	90.25	180	16245	15672.	3874.	10879.	27.2	24.5	2.694	2.792	1.010
23822	90.25	180.	16245	15733.	8310.	21657.	14.7	20.0	2.704	2.792	1.428
23823	90.25	180.	16245	15958.	13752.	31682.	14.2	18.1	2.743	2.792	2.364
23824	90.25	180	16245	16039.	13863.	20316.	19.4	23.3	2.757	2.792	2.383
23825	90.25	180	16245.	16086.	13607.	16758	18.3	23.0	2.765	2.792	2.339

DOUBLE PARALLEL FINS: 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
23831	22.50	340	7650.	7566.	4374.	7721.	54.7	54.3	1.300	1.315	0.752
23832	22.50	340	7650.	7597.	5049.	4849.	58.6	54.7	1.306	1.315	0.868
23833				NO TRACE							
23834	22.50	340	7650	7570	4492.	7292.	59.7	34.4	1.301	1.315	0.772
23835	22.50	340	7650	7594.	4136.	4585.	57.4	54.9	1.305	1.315	0.711

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DOUBLE PARALLEL FINS   0.375 inches THICK,  10.0 inches HIGH,   2.0 inches WIDE,   0.0 degrees INCLINATION
-----------------------------------------------------------------------------------------------------------------------
 FIN ID : DROP    : HAMMER : IMPACT : PEAK ENERGY ABSORBED  : PEAK FORCE PER : PERCENT DEFORMATION :   (PEAK ENERGY ABS)/    :
 NUMBER : HEIGHT  : WEIGHT : ENERGY :  BY FIN  (in-lbs)     : UNIT FIN WIDTH :        ( % )        :    (PLASTIC MOMENT)     :
        :         :        :        :  FROM       FROM      :                :              FROM   :                         :
        : (ins)   : (lbs)  : (in-lb): LOADCELL : ACCELRMTR  :    (lbs/in)    : MEASURED : LOADCELL : LOADCELL:THEORY: ACCELRMTR:
-----------------------------------------------------------------------------------------------------------------------
: 23101 : 90.25 :  460.  : 41515 :  41296.  :  19251.  :     65005.     :     15.0 :     16.4 :  7.098 : 7.136:   3.309  :
: 23102 : 90.25 :  460.  : 41515 :  40969.  :  15406.  :     67646.     :     20.9 :     22.0 :  7.042 : 7.136:   2.648  :
: 23103 : 90.25 :  460   : 41515 :  40986.  :  24682.  :     70970.     :     22.9 :     23.8 :  7.045 : 7.136:   4.242  :
: 23104 : 90.25 :  460   : 41515 :  40947.  :  10439.  :     75802.     :     21.7 :     23.4 :  7.038 : 7.136:   1.794  :
: 23105 : 90.25 :  460   : 41515 :  40884.  :  22497.  :     80659.     :     15.4 :     17.0 :  7.027 : 7.136:   3.867  :
-----------------------------------------------------------------------------------------------------------------------

DOUBLE PARALLEL FINS   0.375 inches THICK,  10.0 inches HIGH,   2.0 inches WIDE,  10.0 degrees INCLINATION
-----------------------------------------------------------------------------------------------------------------------
 FIN ID : DROP    : HAMMER : IMPACT : PEAK ENERGY ABSORBED  : PEAK FORCE PER : PERCENT DEFORMATION :   (PEAK ENERGY ABS)/    :
 NUMBER : HEIGHT  : WEIGHT : ENERGY :  BY FIN  (in-lbs)     : UNIT FIN WIDTH :        ( % )        :    (PLASTIC MOMENT)     :
        :         :        :        :  FROM       FROM      :                :              FROM   :                         :
        : (ins)   : (lbs)  : (in-lb): LOADCELL : ACCELRMTR  :    (lbs/in)    : MEASURED : LOADCELL : LOADCELL:THEORY: ACCELRMTR:
-----------------------------------------------------------------------------------------------------------------------
: 23111   - - - - - - - - - - - - - - - NO TRACE - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -:
: 23112 : 90.25 :  420.  : 37905 :  27350   :  23162.  :     58992.     :     83.7 :     32.5 :  4.701 : 6.515:   3.981  :
: 23113 : 90.25 :  380.  : 34295 :  26083.  :  23307.  :     57368.     :     63.6 :     33.0 :  4.483 : 5.895:   4.006  :
: 23114 : 90.25 :  380   : 34295 :  23957.  :  24208.  :     67683.     :     81.2 :     34.0 :  4.118 : 5.895:   4.161  :
: 23115 : 90.25 :  380.  : 34295 :  24753.  :  26843.  :     57464.     :     74.5 :     33.7 :  4.255 : 5.895:   4.614  :
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DOUBLE PARALLEL FINS   0.375 inches THICK,  10.0 inches HIGH,   2.0 inches WIDE,  20.0 degrees INCLINATION
-----------------------------------------------------------------------------------------------------------------------
 FIN ID : DROP    : HAMMER : IMPACT : PEAK ENERGY ABSORBED  : PEAK FORCE PER : PERCENT DEFORMATION :   (PEAK ENERGY ABS)/    :
 NUMBER : HEIGHT  : WEIGHT : ENERGY :  BY FIN  (in-lbs)     : UNIT FIN WIDTH :        ( % )        :    (PLASTIC MOMENT)     :
        :         :        :        :  FROM       FROM      :                :              FROM   :                         :
        : (ins)   : (lbs)  : (in-lb): LOADCELL : ACCELRMTR  :    (lbs/in)    : MEASURED : LOADCELL : LOADCELL:THEORY: ACCELRMTR:
-----------------------------------------------------------------------------------------------------------------------
: 23121 : 22.50 :  300   :  6750 :   6683.  :   5516.  :     10000.     :     18.8 :     16.9 :  1.149 : 1.160:   0.948  :
: 23122 : 22.50 :  380   :  8550 :   8248.  :   4583.  :     10130.     :      6.2 :      9.6 :  1.418 : 1.470:   0.788  :
: 23123 : 90.25 :  100   :  9025 :   8714.  :    814.  :     11486.     :     22.5 :     31.9 :  1.498 : 1.551:   0.140  :
: 23124 : 22.50 :  380.  :  8550 :   8222.  :   2952.  :     13118.     :      5.0 :      8.5 :  1.413 : 1.470:   0.507  :
: 23125 : 22.50 :  380.  :  8550 :   8238.  :   6108.  :     12175.     :      6.7 :      9.7 :  1.416 : 1.470:   1.050  :
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DOUBLE PARALLEL FINS   0.375 inches THICK,  10.0 inches HIGH,   2.0 inches WIDE,  30.0 degrees INCLINATION
-----------------------------------------------------------------------------------------------------------------------
 FIN ID : DROP    : HAMMER : IMPACT : PEAK ENERGY ABSORBED  : PEAK FORCE PER : PERCENT DEFORMATION :   (PEAK ENERGY ABS)/    :
 NUMBER : HEIGHT  : WEIGHT : ENERGY :  BY FIN  (in-lbs)     : UNIT FIN WIDTH :        ( % )        :    (PLASTIC MOMENT)     :
        :         :        :        :  FROM       FROM      :                :              FROM   :                         :
        : (ins)   : (lbs)  : (in-lb): LOADCELL : ACCELRMTR  :    (lbs/in)    : MEASURED : LOADCELL : LOADCELL:THEORY: ACCELRMTR:
-----------------------------------------------------------------------------------------------------------------------
: 23131   - - - - - - - - - - - - - - - NO TRACE - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -:
: 23132   - - - - - - - - - - - - - - - NO TRACE - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -:
: 23133   - - - - - - - - - - - - - - - NO TRACE - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -:
: 23134 : 22.50 :  260   :  5850 :   5815.  :   3922.  :      2505.     :     48.7 :     50.1 :  0.999 : 1.006:   0.674  :
: 23135 : 22.50 :  260.  :  5850 :   5797.  :    555.  :      4387.     :     48.3 :     36.7 :  0.996 : 1.006:   0.095  :
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TRIPLE UNEQUAL FINS: 0.250 inches THICK. 3.5 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) ACCELRMTR
32301	90.25	380.	34295.	34056.	7474.	33771.	66.3	64.4	9.118	9.182	2.001
32302	90.25	380.	34275.	34019.	20584.	42311.	55.1	55.8	9.108	9.182	5.511
32303	90.25	380.	34275.	33982.	15603.	40204.	51.7	52.4	9.098	9.182	4.178
32304	90.25	380.	34295.	34025.	8952.	33429.	56.3	57.0	9.110	9.182	2.397
32305	90.25	380.	34295.	34042.	20902.	35741.	58.6	60.0	9.114	9.182	5.596

TRIPLE UNEQUAL FINS: 0.250 inches THICK. 4.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) ACCELRMTR
32401	90.25	420.	37905.	36373.	19535.	39381.	75.4	70.6	9.738	10.149	5.230
32402	90.25	380.	34295.	34056.	22141.	38252.	71.5	70.9	9.118	9.182	5.928
32403	90.25	380.	34295.	34066.	9061.	36242.	72.5	69.6	9.121	9.182	2.426
32404	90.25	380.	34295.	34060.	15186.	37962.	70.5	69.3	9.119	9.182	4.066
32405	90.25	380.	34295.	34077.	21661.	36377.	73.5	72.2	9.124	9.182	5.799

TRIPLE UNEQUAL FINS: 0.250 inches THICK. 6.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) ACCELRMTR
32601	90.25	420.	37905.	28100.	33701.	29676.	74.5	60.5	7.523	10.149	9.023
32602	90.25	420.	37905.	37704.	26439.	26442.	73.2	72.2	10.095	10.149	7.079
32603	90.25	340.	30685.	29109.	21377.	38982.	48.8	43.5	7.794	8.216	5.723
32604	90.25	340.	30685.	28134.	25534.	27797.	58.2	48.0	7.532	8.216	6.836
32605	90.25	340.	30685.	30485.	18167.	28143.	60.0	55.9	8.162	8.216	4.864

TRIPLE UNEQUAL FINS: 0.250 inches THICK. 8.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) ACCELRMTR
32801	90.25	340	30685.	30530.	20617.	29978.	59.8	53.0	8.174	8.216	5.320
32802	90.25	340	30685.	30527.	14550.	24644.	55.8	52.9	8.173	8.216	3.896
32803				NO TRACE							
32804	90.25	340	30685.	26352.	14221.	25813.	58.3	37.6	7.055	8.216	3.807
32805	90.25	340	30685.	28231.	16708.	26113.	55.8	32.2	7.559	8.216	4.473

TRIPLE UNEQUAL FINS. 0.250 inches THICK. 10.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
32101	90.25	300.	27075	26853.	2622.	25504.	83.1	73.5	7.190	7.249	0.702
32102	90.25	260.	23465	22998.	0.	27865.	65.0	63.6	6.158	6.282	0.000
32103	90.25	260.	23465	23204.	5844.	26269.	59.5	61.1	6.213	6.282	1.565
32104	90.25	260	23465	23249.	7780.	24250.	56.0	56.4	6.225	6.282	2.083
32105	90.25	260.	23465.	23231.	3437.	25145.	59.1	67.2	6.220	6.282	0.920

TRIPLE UNEQUAL FINS. 0.375 inches THICK, 3.5 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
33301	90.25	565	50991.	50737.	29640.	58863.	26.0	28.4	5.814	5.843	3.396
33302	90.25	565	50991.	50707.	20467.	65966.	23.7	25.5	5.810	5.843	2.345
33303	90.25	565	50991	50692.	28348.	75851.	23.7	24.9	5.809	5.843	3.248
33304	90.25	565.	50991	50611.	29738.	126259.	18.0	20.3	5.799	5.843	3.408
33305	90.25	565.	50991	50681.	24912.	62580.	21.4	24.5	5.807	5.843	2.855

TRIPLE UNEQUAL FINS: 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
33401	90.25	565.	50991	50330.	33384.	105330.	28.3	28.6	5.767	5.843	3.825
33402	90.25	565.	50991.	50807.	26899.	58964.	36.3	40.0	5.822	5.843	3.082
33403	90.25	565.	50991	50742.	36042.	55605.	22.3	26.1	5.814	5.843	4.130
33404	90.25	565.	50991.	50769.	18017.	74695.	28.3	31.6	5.817	5.843	2.065
33405	90.25	565.	50991.	50787.	24641.	59910.	30.3	34.1	5.820	5.843	2.824

TRIPLE UNEQUAL FINS: 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
33601	90.25	485.	43771	43417.	28741.	47637.	32.5	37.1	4.975	5.016	3.293
33602	90.25	485.	43771.	43341.	15796.	49429.	27.2	32.1	4.966	5.016	1.810
33603	90.25	485.	43771.	43334.	31560.	53911.	27.2	32.6	4.965	5.016	3.616
33604	90.25	485.	43771.	43391.	33648.	52354.	28.5	30.8	4.972	5.016	3.856
33605	90.25	485.	43771.	43418.	31272.	41918.	29.8	34.9	4.975	5.016	3.583

TRIPLE UNEQUAL FINS: 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
33801	90.25	485	43771.	43456.	31749.	41681.	34.1	42.7	4.980	5.016	3.638
33802	90.25	485	43771	43479.	29796.	35461.	27.2	32.6	4.982	5.016	3.414
33803	90.25	485	43771.	43360.	31234.	43243.	22.3	19.5	4.969	5.016	3.579
33804	90.25	485.	43771.	43286.	25943.	46706.	18.9	17.2	4.960	5.016	2.973
33805	90.25	485.	43771.	43375.	30898.	42647.	23.8	20.1	4.970	5.016	3.540

TRIPLE UNEQUAL FINS 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
33101	90.25	405	36551.	35051.	569.	55978.	26.0	39.8	4.016	4.188	0.065
33102	90.25	405	36551.	35750.	3342.	43971.	32.7	45.7	4.096	4.188	0.383
33103				NO TRACE							
33104	90.25	405	36551.	36126.	19730.	98406.	18.9	24.5	4.140	4.188	2.261
33105				NO TRACE							

DOUBLE CONVERGING FINS 0.250 inches THICK. 3.5 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
42301	90.25	340	30685.	30523.	17737.	56647.	45.1	45.1	12.258	12.323	7.123
42302	90.25	340.	30685.	30535.	13765.	53512	46.3	46.3	12.263	12.323	6.331
42303	90.25	340	30685	30523.	17737	56647.	45.1	45.1	12.258	12.323	7.123
42304				NO TRACE							
42305	90.25	340.	30685.	30523.	17737.	56647.	45.1	45.1	12.258	12.323	7.123

DOUBLE CONVERGING FINS: 0.250 inches THICK. 4.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
42401	90.25	340.	30685	30221.	11114.	53928.	41.0	40.9	12.137	12.323	4.464
42402	90.25	340.	30685.	30519.	13075.	53357.	43.0	44.2	12.257	12.323	6.054
42403	90.25	340.	30685	30536.	10177.	54869.	46.0	47.4	12.263	12.323	4.087
42404	90.25	340.	30685.	30461.	14884.	56737.	44.0	48.4	12.233	12.323	5.978
42405	90.25	340	30685.	30536.	18530.	56286.	49.0	47.3	12.264	12.323	7.442

DOUBLE CONVERGING FINS: 0.250 inches THICK. 6.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
42601	90.25	340.	30685.	30061.	20748.	48959.	32.2	67.2	12.073	12.323	8.332
42602	90.25	340.	30685.	29961.	24352.	52206.	39.7	50.6	12.032	12.323	9.780
42603	90.25	340.	30685.	30331.	16836.	57217.	48.8	46.5	12.181	12.323	6.761
42604	90.25	340.	30685.	30363.	21044.	50915.	48.2	51.4	12.194	12.323	8.452
42605	90.25	340.	30685.	30282.	8057.	57362.	35.2	34.6	12.161	12.323	3.236

DOUBLE CONVERGING FINS: 0.250 inches THICK. 8.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
42801				NO TRACE							
42802	90.25	260	23465	23051.	18345	57098.	24.3	23.0	9.257	9.424	7.367
42803	90.25	260	23465	23132.	18247.	49936.	31.1	31.6	9.290	9.424	7.328
42804	90.25	260	23465	23066.	6881.	54341.	27.2	27.6	9.263	9.424	2.763
42805	90.25	260	23465	23115.	16541.	52100.	26.2	27.1	9.283	9.424	6.643

DOUBLE CONVERGING FINS 0.250 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) ACCELRMTR
42101	90.25	180	16245.	16053.	6320.	49713.	7.9	10.4	6.447	6.524	2.538
42102	90.25	260	23465.	19736.	15714.	54682.	39.4	24.7	7.926	9.424	6.311
42103	90.25	260.	23465	23145.	18112	51363.	28.0	30.0	9.295	9.424	7.274
42104	90.25	260	23465.	23165.	17099.	51382.	30.8	31.8	9.303	9.424	6.867
42105	90.25	260.	23465.	23233.	5945.	37165.	29.2	29.9	9.330	9.424	2.388

DOUBLE CONVERGING FINS 0.375 inches THICK. 3.5 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
43301	90.25	365.	50991	47481.	0.	88484.	20.3	19.6	8.161	8.764	0.000
43302	NO TRACE										
43303	90.25	365.	50991	47322.	0.	62724.	16.9	18.9	8.134	8.764	0.000
43304	90.25	485	43771	43338.	14114.	84902.	16.9	14.2	7.449	7.523	2.426
43305	90.25	365.	50991.	50630.	7448.	76945.	19.1	20.1	8.702	8.764	1.280

DOUBLE CONVERGING FINS: 0.375 inches THICK. 4.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
43401	90.25	485	43771.	39746.	15172.	66534.	8.5	13.2	6.831	7.523	2.608
43402	90.25	485.	43771.	42140.	0.	202378.	17.5	17.2	7.243	7.523	0.000
43403	90.25	485.	43771	40623.	20180.	58523.	15.5	17.0	6.982	7.523	3.469
43404	90.25	485	43771	40465	13432.	82506.	16.5	16.6	6.955	7.523	2.309
43405	90.25	485	43771.	40408.	9647.	68830.	16.5	15.8	6.945	7.523	1.658

DOUBLE CONVERGING FINS: 0.375 inches THICK. 6.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
43601	90.25	485.	43771.	31576.	34851.	81375.	25.3	52.5	5.427	7.523	5.990
43602	90.25	485.	43771.	43072.	9067.	106189.	32.5	30.3	7.403	7.523	1.558
43603	90.25	485.	43771.	43207.	30803.	71002.	20.7	23.1	7.426	7.523	5.294
43604	90.25	485.	43771.	42714.	3533.	74532.	29.2	26.9	7.342	7.523	0.607
43605	90.25	485.	43771.	42712.	21837.	79023.	30.5	28.9	7.341	7.523	3.753

DOUBLE CONVERGING FINS: 0.375 inches THICK. 8.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
43801	90.25	405.	36551.	36313.	30690.	68625.	12.0	14.7	6.242	6.282	5.275
43802	NO TRACE										
43803	90.25	405	36551	36318.	33554.	120230.	15.9	17.7	6.242	6.282	5.767
43804	90.25	405.	36551	35360.	13838.	94488.	25.3	23.5	6.078	6.282	2.379
43805	90.25	405	36551	36304.	31382	202227.	12.0	14.2	6.240	6.282	5.394

DOUBLE CONVERGING FINS: 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
43101	90.25	460	41515.	40885.	22138.	81723	15.0	16.0	7.027	7.136	3.809
43102	90.25	460.	41515.	40935.	27143.	76852.	16.6	18.0	7.036	7.136	4.665
43103	90.25	460.	41515.	41049.	10017.	67690.	28.4	30.2	7.056	7.136	1.722
43104	90.25	460	41515	40790.	23255.	79558.	10.3	10.8	7.011	7.136	3.997
43105	90.25	460	41515.	40055.	20904.	83406.	22.1	20.4	6.885	7.136	3.593

DOUBLE BRACED FINS. 0.250 inches THICK. 3.5 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
52301	90.25	340	30685.	30548.	21549.	49250.	45.1	48.6	12.268	12.323	8.654
52302	90.25	340.	30685.	30540.	18792.	50332.	45.1	47.6	12.265	12.323	7.547
52303	90.25	340.	30685.	30537.	21359.	49791.	42.9	47.1	12.264	12.323	8.578
52304	90.25	340	30685.	30555.	24745.	46459.	47.1	51.1	12.271	12.323	9.938
52305	90.25	340.	30685.	30547.	21579.	47595.	45.1	49.1	12.268	12.323	8.666

DOUBLE BRACED FINS: 0.250 inches THICK. 4.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
52401	90.25	340.	30685.	30345.	13484.	49753.	47.0	49.3	12.187	12.323	5.415
52402	90.25	340.	30685.	30384.	15034.	44225.	49.0	53.4	12.202	12.323	6.038
52403	90.25	340.	30685.	30359.	19477.	47510.	48.0	51.1	12.193	12.323	7.822
52404	90.25	340.	30685.	30366.	15342.	49791.	48.0	52.1	12.195	12.323	6.161
52405	90.25	340.	30685.	30391.	20766.	45462.	51.0	54.3	12.205	12.323	8.340

DOUBLE BRACED FINS: 0.250 inches THICK. 6.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
52601	90.25	340.	30685.	30422.	9109.	46544.	54.8	54.3	12.218	12.323	3.658
52602	90.25	340.	30685.	30384.	9544.	53580.	53.5	52.6	12.202	12.323	3.833
52603	90.25	340.	30685.	30407.	9173.	65409.	50.2	51.6	12.212	12.323	3.684
52604	90.25	340.	30685.	30335.	10155.	50332.	45.7	45.0	12.183	12.323	4.078
52605	90.25	340	30685.	30395.	9802.	50874.	47.0	48.0	12.207	12.323	3.937

DOUBLE BRACED FINS: 0.250 inches THICK. 8.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
52801	90.25	260	23465.	23165.	18716.	46003.	34.1	34.1	9.303	9.424	7.517
52802	90.25	260	23465	22624.	13687.	50582.	27.2	45.5	9.086	9.424	5.497
52803	90.25	260	23465	23096.	1930.	46119.	30.6	40.1	9.276	9.424	0.775
52804	90.25	260	23465	23097.	9304.	48348.	24.8	28.9	9.276	9.424	3.736
52805	90.25	260	23465	22715.	15231.	47377.	29.8	44.5	9.122	9.424	6.117

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DOUBLE BRACED FINS:   0.250 inches THICK,  10.0 inches HIGH,   2.0 inches WIDE,   0.0 degrees INCLINATION
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 FIN ID : DROP    :  HAMMER :  IMPACT : PEAK ENERGY ABSORBED  : PEAK FORCE PER : PERCENT DEFORMATION :  (PEAK ENERGY ABS)/      :
 NUMBER : HEIGHT  :  WEIGHT :  ENERGY :  BY FIN   (in-lbs)    : UNIT FIN WIDTH :        ( % )        :   (PLASTIC MOMENT)       :
        :         :         :         :   FROM       FROM     :                :             FROM    :                          :
        :  (ins)  :  (lbs)  : (in-lb) : LOADCELL : ACCELRMTR  :    (lbs/in)    : MEASURED : LOADCELL : LOADCELL:THEORY: ACCELRMTR:
---------------------------------------------------------------------------------------------------------------------------
: 52101 :  90.25  :   260   :  23465. :  23204.  :    8037.   :     43055.     :    24.1  :    28.3  :  9.319 : 9.424:   3.228   :
: 52102 :  90.25  :    90.  :   8145. :   7273.  :       0.   :     50356.     :    21.3  :     1.3  :  2.921 : 3.271:   0.000   :
: 52103 :  90.25  :   260.  :  23465. :  23227   :   12677.   :     40543      :    31.9  :    34.8  :  9.328 : 9.424:   5.091   :
: 52104 :  90.25  :   260.  :  23465. :  23179.  :   15591.   :     43775.     :    27.6  :    31.8  :  9.309 : 9.424:   6.261   :
: 52105 :  90.25  :   260.  :  23465. :  23179.  :   21399.   :     40108.     :    32.7  :    36.7  :  9.309 : 9.424:   8.594   :
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DOUBLE BRACED FINS 0.375 inches THICK, 3.5 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
53301	90.25	565.	50991.	50243.	0.	68070.	19.1	25.6	8.636	8.764	0.000
53302	90.25	565	50991.	50697.	26310.	202813.	18.0	25.0	8.714	8.764	4.522
53303	90.25	565	50991.	50681.	31829.	70649.	18.0	24.6	8.711	8.764	5.471
53304	90.25	565.	50991.	50701.	14922.	66861.	20.3	26.1	8.714	8.764	2.565
53305	90.25	565	50991.	50714.	41160.	63207.	21.4	27.6	8.717	8.764	7.075

DOUBLE BRACED FINS: 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
53401	90.25	485.	43771	41228.	0.	59747.	14.5	22.0	7.086	7.523	0.000
53402	90.25	485.	43771.	41188.	14419.	114821.	15.5	21.0	7.079	7.523	2.478
53403	90.25	485.	43771.	41062.	0.	71578.	13.5	21.5	7.058	7.523	0.000
53404	90.25	485.	43771.	41202.	0.	70895.	16.5	22.2	7.082	7.523	0.000
53405	90.25	485.	43771.	41446.	0.	58413.	15.5	24.9	7.124	7.523	0.000

DOUBLE BRACED FINS: 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
53601	90.25	485.	43771.	42805	15142.	70904.	21.3	27.4	7.357	7.523	2.603
53602	90.25	485.	43771.	41598.	11543.	76801.	19.3	24.1	7.150	7.523	1.984
53603	90.25	485	43771.	42317.	5304.	193688.	27.8	33.6	7.274	7.523	0.912
53604	90.25	485.	43771	41658.	14588.	77684.	19.3	24.3	7.160	7.523	2.507
53605	90.25	485.	43771.	41795.	8412.	69171.	27.2	28.3	7.184	7.523	1.446

DOUBLE BRACED FINS 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
53801	90.25	405	36551.	36319.	8096.	74539.	10.5	15.0	6.242	6.282	1.392
53802	90.25	405.	36551	36155.	8500.	66561.	13.5	20.3	6.214	6.282	1.461
53803	90.25	405.	36551.	36097.	18678.	202875.	18.4	21.3	6.204	6.282	3.210
53804	90.25	405	36551	36220.	10860.	78838.	17.9	21.1	6.226	6.282	1.867
53805				NO TRACE							

DOUBLE BRACED FINS 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) ACCELRMTR
53101	90.25	460	41515.	41029.	20505.	71517.	24.1	27.2	7.052	7.136	3.524
53102	90.25	460	41515.	40920.	16299.	75808.	17.0	20.5	7.033	7.136	2.801
53103	90.25	460	41515.	41091.	23843.	62281.	25.6	28.4	7.063	7.136	4.098
53104	90.25	460	41515.	41015.	25709.	65602	17.4	20.6	7.050	7.136	4.419
53105	90.25	460.	41515.	40998.	14851.	69855.	19.3	22.6	7.047	7.136	2.553

OAK RIDGE FIN 0.250 inches THICK. 3.5 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
62301	90.25	180	16245.	16086.	7336	23324.	51.7	57.0	12.921	13.048	5.892
62302	90.25	180	16245	16166.	10018	28159.	47.1	51.8	12.984	13.048	8.047
62303	90.25	180	16245	16171.	9503	25771.	50.6	54.5	12.989	13.048	7.633
62304	90.25	180	16245.	16175.	13171	24391.	50.6	56.7	12.992	13.048	10.579
62305	90.25	180	16245	16178.	10393	29002.	51.7	56.1	12.994	13.048	8.348

OAK RIDGE FIN 0.250 inches THICK. 4.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
62401	90.25	220	19855.	19699.	7319.	23016.	75.5	76.4	15.823	15.948	5.879
62402	90.25	180	16245	16095.	11209.	24815.	54.8	57.3	12.928	13.048	9.003
62403	90.25	180	16245.	16093.	7486.	23747.	52.8	57.0	12.926	13.048	6.013
62404	90.25	180	16245	16091.	11959.	25510.	52.8	55.3	12.925	13.048	9.606
62405	90.25	180	16245	16173.	9213.	24721.	51.0	53.9	12.990	13.048	7.400

OAK RIDGE FIN: 0.250 inches THICK. 6.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
62601	90.25	180	16245.	16016.	0.	21429.	61.3	57.9	12.864	13.048	0.000
62602	90.25	180	16245.	15799.	0.	21321.	47.5	48.2	12.690	13.048	0.000
62603	90.25	180	16245	15995.	0.	21276.	62.0	60.8	12.848	13.048	0.000
62604	90.25	180	16245.	16026.	0.	21956.	62.7	66.2	12.872	13.048	0.000
62605	90.25	180	16245	15996.	0.	21332.	45.0	45.0	12.848	13.048	0.000

OAK RIDGE FIN 0.250 inches THICK. 8.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
62801	90.25	140	12635	12367.	0.	18176.	53.8	58.5	9.934	10.149	0.000
62802	90.25	140	12635	12369.	0	21251.	35.6	36.6	9.935	10.149	0.000
62803	90.25	140	12635	12403.	0	21106	33.1	33.0	9.963	10.149	0.000
62804	90.25	140	12635	12337.	0	21268	19.9	20.7	9.909	10.149	0.000
62805	90.25	140	12635.	12348.	0	21266.	22.3	23.4	9.918	10.149	0.000

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OAK RIDGE FIN    0.250 inches THICK.  10.0 inches HIGH.   2.0 inches WIDE.   0.0 degrees INCLINATION
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 FIN ID : DROP    :  HAMMER : IMPACT : PEAK ENERGY ABSORBED   | PEAK FORCE PER | PERCENT DEFORMATION :    (PEAK ENERGY ABS)/     :
 NUMBER : HEIGHT  :  WEIGHT : ENERGY :   BY FIN  (in-lbs)     | UNIT FIN WIDTH |         ( % )       :     (PLASTIC MOMENT)      :
        :         :         :        :   FROM       FROM      |                :            FROM     :                           :
        : (ins)   :   (lbs) : (in-lb): LOADCELL : ACCELRMTR   |    (lbs/in)    | MEASURED | LOADCELL : LOADCELL:THEORY: ACCELRMTR:
------------------------------------------------------------------------------------------------------------------------------
: 62101   - - - - - - - - - - - - - - - NO TRACE - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - :
: 62102 : 120.00  :   140   : 16800  :   8082   :   7237.     |     4842       |     20.0 |     62.1 :  6.491 :13.494:  5.813    :
: 62103   - - - - - - - - - - - - - - - NO TRACE - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - :
: 62104 : 120.00  |   220   | 26400  :     0.   |  17327.     |        0.      |     81.3 :      0.0 |  0.000 |21.205:  13.917   :
: 62105 : 120.00  :   180   | 21600. :   8409.  |  16850.     |     5302.      |     78.8 |    101.1 |  6.754 |17.349:  13.534   :
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OAK RIDGE FIN: 0.375 inches THICK. 3.5 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
63301	90.25	340.	30685	30524.	5086.	39617.	29.1	29.6	10.493	10.548	1.748
63302	90.25	340	30685	30534.	14025.	39892.	32.6	33.0	10.496	10.548	4.821
63303	90.25	340	30685	30514.	21039.	40045.	27.1	27.7	10.489	10.548	7.232
63304	90.25	340	30685	30524.	12547.	40605.	29.1	29.7	10.493	10.548	4.313
63305	90.25	340	30685.	30522.	18462.	40525.	29.1	30.1	10.492	10.548	6.347

OAK RIDGE FIN: 0.375 inches THICK. 4.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
63401	90.25	220	19855	19577.	10685.	44809.	7.5	9.1	6.730	6.825	3.673
63402	90.25	260	23465.	23310.	12657.	38935.	21.5	21.9	8.013	8.066	4.351
63403	90.25	260	23465	23200	14988.	44889.	10.5	11.1	7.975	8.066	5.152
63404	90.25	260	23465.	23293.	16785.	40018.	18.5	19.3	8.007	8.066	5.770
63405	90.25	260	23465	23267	12317.	42724.	16.5	15.9	7.998	8.066	4.234

OAK RIDGE FIN: 0.375 inches THICK. 6.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
63601	90.25	180	16245	15907.	0.	21358.	12.8	19.4	5.468	5.584	0.000
63602	90.25	180	16245	15840.	0.	29380.	16.2	17.3	5.445	5.584	0.000
63603	90.25	180	16245	15799.	0.	29548.	13.5	15.2	5.431	5.584	0.000
63604	90.25	180	16245	15797.	0.	29411.	12.8	15.4	5.430	5.584	0.000
63605	90.25	180.	16245	15797.	0.	29087.	12.8	15.0	5.430	5.584	0.000

OAK RIDGE FIN: 0.375 inches THICK. 8.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
63801	90.25	180	16245.	15758.	0.	29429.	9.0	14.1	5.417	5.584	0.000
63802	90.25	220.	19855	19115.	11327.	44409.	24.3	23.9	6.571	6.825	3.894
63803	90.25	220	19855	19264.	8768.	44169.	21.4	21.7	6.622	6.825	3.014
63804	90.25	220	19855	19490.	14689.	44874.	21.9	21.4	6.700	6.825	5.049
63805	90.25	220	19855	19426.	9809.	38939.	24.8	24.2	6.678	6.825	3.372

OAK RIDGE FIN   0.375 inches THICK.   10.0 inches HIGH.   2.0 inches WIDE.   0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ABS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
63101	90.25	180	16245	15823.	6795.	35240.	9.1	11.4	5.439	5.584	2.336
63102	90.25	220	19855.	19478.	12682.	41721.	29.6	32.1	6.696	6.825	4.359
63103	- - - - - - - - - - - - - - - - - - -	- - NO TRACE - -	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -
63104	90.25	220	19855.	18849.	13583.	43240.	28.4	23.2	6.479	6.823	5.357
63105	90.25	220	19855	19142.	12903.	42898.	19.3	19.7	6.580	6.825	4.436

OAK RIDGE FIN: 0.250 inches THICK. 3.5 inches HIGH. 2.0 inches WIDE. 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT	HAMMER WEIGHT	IMPACT ENERGY	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
	(ins)	(lbs)	(in-lb)	FROM LOADCELL	FROM ACCELRMTR	(lbs/in)	MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
62331	22.50	140.	3150	3109.	0.	2971.	71.6	77.0	2.497	2.530	0.000
62332	22.50	100.	2250	2230.	0.	2932.	32.2	63.1	1.791	1.807	0.000
62333	22.50	100.	2250	2235.	0.	1974.	57.4	67.7	1.795	1.807	0.000
62334	22.50	100.	2250.	2236.	0.	1688.	59.8	69.8	1.796	1.807	0.000
62335	22.50	100.	2250.	2235.	0.	1927.	58.4	68.9	1.795	1.807	0.000

OAK RIDGE FIN: 0.250 inches THICK. 4.0 inches HIGH. 2.0 inches WIDE. 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT	HAMMER WEIGHT	IMPACT ENERGY	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
	(ins)	(lbs)	(in-lb)	FROM LOADCELL	FROM ACCELRMTR	(lbs/in)	MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
62431	22.50	140.	3150	3109.	0.	3131.	75.2	79.7	2.497	2.530	0.000
62432	22.50	100.	2250.	2241.	0.	2908.	57.0	66.1	1.800	1.807	0.000
62433	22.50	100.	2250.	2234.	0.	2127.	61.6	71.6	1.794	1.807	0.000
62434	22.50	100.	2250	2235.	0.	2580.	55.8	65.2	1.795	1.807	0.000
62435	22.50	100.	2250	2237.	0.	2091.	61.6	69.5	1.797	1.807	0.000

OAK RIDGE FIN: 0.250 inches THICK. 6.0 inches HIGH. 2.0 inches WIDE. 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT	HAMMER WEIGHT	IMPACT ENERGY	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
	(ins)	(lbs)	(in-lb)	FROM LOADCELL	FROM ACCELRMTR	(lbs/in)	MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
62631	22.50	100.	2250.	2241.	0.	1727.	72.1	78.7	1.800	1.807	0.000
62632	18.62	100	1862.	1813.	89.	2101.	27.3	54.0	1.457	1.496	0.072
62633	22.50	100.	2250	2236.	0.	1364.	78.1	78.5	1.796	1.807	0.000
62634				NO TRACE							
62635	18.62	100.	1862	1856.	851.	783.	61.5	65.9	1.490	1.496	0.684

OAK RIDGE FIN: 0.250 inches THICK. 8.0 inches HIGH. 2.0 inches WIDE. 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT	HAMMER WEIGHT	IMPACT ENERGY	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
	(ins)	(lbs)	(in-lb)	FROM LOADCELL	FROM ACCELRMTR	(lbs/in)	MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
62831	18.62	100	1862	1755.	0.	2714.	76.8	74.9	1.409	1.496	0.000
62832	18.62	100	1862	1842.	0.	994.	80.8	84.2	1.479	1.496	0.000
62833	15.00	100	1500	1492.	495.	916.	66.5	66.0	1.198	1.205	0.398
62834				NO TRACE							
62835	15.00	100	1500	1491.	0.	1145.	66.5	64.1	1.197	1.205	0.000

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OAK RIDGE FIN.   0.250 inches THICK.  10.0 inches HIGH.   2.0 inches WIDE.  30.0 degrees INCLINATION
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 FIN ID : DROP    :  HAMMER :  IMPACT :  PEAK ENERGY ABSORBED   : PEAK FORCE PER  : PERCENT DEFORMATION :      (PEAK ENERGY ABS)/        :
 NUMBER : HEIGHT  :  WEIGHT :  ENERGY :    BY FIN   (in-lbs)    : UNIT FIN WIDTH  :        ( % )        :       (PLASTIC MOMENT)         :
        :         :         :         :    FROM        FROM     :                 :              FROM   :                                :
        :  (ins)  :   (lbs) : (in-lb) :  LOADCELL :  ACCELRMTR  :    (lbs/in)     : MEASURED : LOADCELL : LOADCELL:THEORY: ACCELRMTR:
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: 62131 :  12.00  :   100   :   1200  :   1195.   :       0.    :      667.       :    53.7 :     47.9 :  0.959 : 0.964:   0.000   :
: 62132 :  12.00  :   100   :   1200  :   1135.   :       0.    :     2152.       :    46.4 :     36.4 :  0.912 : 0.964:   0.000   :
: 62133 :  12.00  :   100   :   1200  :   1138.   :       0.    :     1957.       :    52.8 :     45.2 :  0.930 : 0.964:   0.000   :
: 62134 :  12.00  :   100   :   1200  :   1186.   :       0.    :      650.       :    60.5 :     55.9 :  0.953 : 0.964:   0.000   :
: 62135 :  12.00  :   100   :   1200  :   1187.   :       0.    :      511.       :    56.8 :     50.6 :  0.953 : 0.964:   0.000   :
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OAK RIDGE FIN: 0.375 inches THICK, 3.5 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
63331	22.50	180	4050	4014.	0.	4623.	19.5	26.0	1.380	1.392	0.000
63332	22.50	180	4050	4037.	0.	4957.	30.1	34.8	1.388	1.392	0.000
63333	22.50	180	4050	4024.	0.	4770.	26.1	32.9	1.383	1.392	0.000
63334	22.50	180	4050	4021	0.	4784.	22.1	28.4	1.382	1.392	0.000
63335	22.50	180	4050	4018.	0.	4952.	20.8	26.5	1.381	1.392	0.000

OAK RIDGE FIN: 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
63431	22.50	180	4050	4015	0.	2106.	34.2	46.6	1.380	1.392	0.000
63432	22.50	180	4050.	4026.	0.	4811.	27.3	32.5	1.384	1.392	0.000
63433	22.50	180	4050	4024.	0.	4782.	27.3	30.2	1.383	1.392	0.000
63434	22.50	180	4050	4028	0.	3946.	29.6	34.8	1.385	1.392	0.000
63435	22.50	180	4050	4022.	0.	4555.	22.9	27.6	1.383	1.392	0.000

OAK RIDGE FIN: 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
63631	- - - -	- - - -	- - - -	NO TRACE	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
63632	- - - -	- - - -	- - - -	NO TRACE	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
63633	22.50	180.	4050	4016.	0.	1569.	53.8	56.0	1.380	1.392	0.000
63634	22.50	180	4050.	4032.	0.	1574.	55.4	54.0	1.386	1.392	0.000
63635	22.50	180	4050.	4031.	0.	1430.	51.5	51.6	1.386	1.392	0.000

OAK RIDGE FIN: 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs)		PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%)		(PEAK ENERGY ABS)/ (PLASTIC MOMENT)		
				FROM LOADCELL	FROM ACCELRMTR		MEASURED	FROM LOADCELL	LOADCELL	THEORY	ACCELRMTR
63831	22.50	140	3150	3103.	0.	3683.	39.8	41.9	1.067	1.083	0.000
63832	22.50	180	4050	4018.	0.	2394.	65.4	61.5	1.381	1.392	0.000
63833	22.50	180.	4050	4023	0.	1760.	67.1	62.0	1.383	1.392	0.000
63834	22.50	180	4050	4022	0.	1985.	67.7	62.3	1.383	1.392	0.000
63835	22.50	180	4050	4022.	0.	2346.	68.8	63.8	1.382	1.392	0.000

OAK RIDGE FIN 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	FROM LOADCELL	(PEAK ENERGY ARS)/ (PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
63131	22.50	100	2250.	2134.	0.	3052.	20.4	25.4	0.734	0.773	0.000
63132				NO TRACE							
63133	22.50	140	3150.	3127.	0.	2433.	52.8	52.5	1.075	1.083	0.000
63134	22.50	100	2250	2218.	0.	2553.	49.5	32.9	0.763	0.773	0.000
63135	22.50	140	3150	3129.	0.	1933.	56.0	53.3	1.076	1.083	0.000

ALL FIN TYPES WITH A 0.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 3.5 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)	5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN (0.250)	4.49	0.24	6.18	0.53	7.30	0.63	7.66	0.28	7.95	0.00						
DOUBLE PARALLEL FINS (0.250)	4.57	0.25	6.10	0.66	7.56	0.85	8.23	1.04	9.10	0.99	9.73	1.01	10.78	0.27		
DOUBLE CONVERGING FINS (0.250)	4.47	0.35	6.12	0.68	7.68	1.00	8.44	1.34	9.30	1.26	9.94	1.24	10.71	0.24		
DOUBLE BRACED FINS (C.250)	4.15	0.17	5.72	0.13	7.24	0.18	7.92	0.20	8.81	0.18	9.62	0.19	10.94	0.26	11.97	0.00
OAK RIDGE FIN (0.250)	4.35	0.32	5.31	0.34	6.48	0.40	7.00	0.35	7.89	0.37	8.21	0.50	9.45	0.34	11.71	0.44
WIDE SINGLE FIN (0.375)	2.97	0.14	5.90	0.19	7.52	0.15										
DOUBLE PARALLEL FINS (0.375)	3.15	0.19	5.40	0.38	7.19	0.18										
DOUBLE CONVERGING FINS (0.375)	3.24	0.07	5.67	0.29	7.09	0.22	8.34	0.33								
DOUBLE BRACED FINS (0.375)	2.35	0.36	4.61	0.22	6.19	0.20	7.44	0.23	8.45	0.19						
OAK RIDGE FIN (0.375)	3.37	0.05	5.58	0.11	7.35	0.13	8.60	0.17	9.61	0.24	10.27	0.17				

ALL FIN TYPES WITH A 0.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 4.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN	(0.250)	4.81	0.41	6.24	0.55	6.96	0.40	7.59	0.23	7.88	0.00						
DOUBLE PARALLEL FINS	(0.250)	5.11	0.39	6.03	0.48	7.47	0.57	8.29	0.79	8.98	0.94	9.64	1.05	10.57	0.47		
DOUBLE CONVERGING FINS	(0.250)	4.93	0.65	5.86	0.45	7.33	0.45	8.03	0.61	8.65	0.61	9.29	0.60	10.72	0.66		
DOUBLE BRACED FINS	(0.250)	4.52	0.25	5.43	0.24	6.86	0.26	7.67	0.34	8.31	0.37	9.00	0.36	10.22	0.40	11.61	0.24
OAK RIDGE FIN	(0.250)	4.33	0.19	4.83	0.22	6.15	0.25	6.49	0.31	7.16	0.27	7.69	0.33	9.30	0.36	11.59	0.29
WIDE SINGLE FIN	(0.375)	3.65	0.13	6.17	0.18	7.54	0.03										
DOUBLE PARALLEL FINS	(0.375)	3.03	0.71	5.05	0.49	6.27	0.44	6.84	0.18								
DOUBLE CONVERGING FINS	(0.375)	3.29	0.70	5.43	0.14	6.63	0.11										
DOUBLE BRACED FINS	(0.375)	2.38	0.60	4.49	0.23	5.68	0.22	6.63	0.22	7.05	0.00						
OAK RIDGE FIN	(0.375)	4.02	0.23	6.23	0.88	7.15	0.51	7.66	0.00								

ALL FIN TYPES WITH A 0.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 6.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN	(0.250)	4.69	0.43	5.70	0.67	6.52	0.91	6.80	0.73	6.82	0.12	7.07	0.14	7.77	0.00		
DOUBLE PARALLEL FINS	(0.250)	5.63	0.43	6.60	0.61	7.23	0.70	7.94	0.72	8.54	0.71	8.98	0.74	10.25	0.55	11.61	0.49
DOUBLE CONVERGING FINS	(0.250)	4.69	1.37	5.39	1.78	6.18	1.48	7.00	1.34	7.63	1.28	8.27	1.45	9.51	1.33	11.02	1.35
DOUBLE BRACED FINS	(0.250)	5.23	0.38	6.40	0.43	7.13	0.53	7.84	0.54	8.46	0.55	9.02	0.65	10.41	0.62	11.64	0.19
OAK RIDGE FIN	(0.250)	6.68	0.35	6.43	0.84	7.30	0.63	8.12	0.56	8.72	0.66	9.08	0.74	10.10	1.09	10.38	0.76
WIDE SINGLE FIN	(0.375)	5.21	0.23	6.38	0.30	7.14	0.23	7.70	0.00								
DOUBLE PARALLEL FINS	(0.375)	3.70	0.24	4.76	0.33	5.58	0.36	6.25	0.40	6.84	0.45	6.85	0.38				
DOUBLE CONVERGING FINS	(0.375)	3.45	0.78	4.46	1.05	5.27	1.23	5.93	1.37	6.20	1.52	5.77	2.17	4.85	0.00	5.27	0.00
DOUBLE BRACED FINS	(0.375)	3.49	0.29	4.67	0.37	5.54	0.41	6.27	0.38	6.68	0.39	6.82	0.00				
OAK RIDGE FIN	(0.375)	3.62	0.23	4.46	0.20	5.17	0.24										

ALL FIN TYPES WITH A 0.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 8.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN	(0.250)	4.69	0.18	5.72	0.20	6.44	0.32	7.05	0.45	7.37	0.27	7.86	0.11				
DOUBLE PARALLEL FINS	(0.250)	4.89	0.38	6.00	0.83	6.90	1.07	6.97	0.24	7.47	0.24	7.96	0.26	9.06	0.11		
DOUBLE CONVERGING FINS	(0.250)	5.45	0.48	6.69	0.51	7.45	0.54	8.07	0.56	8.52	0.34	8.89	0.00				
DOUBLE BRACED FINS	(0.250)	3.83	1.22	5.02	1.27	5.90	1.20	6.58	1.11	7.14	1.10	7.37	0.85	8.55	0.51		
OAK RIDGE FIN	(0.250)	5.35	0.64	6.74	0.94	7.57	1.24	8.20	1.42	7.77	1.38	8.39	1.40	7.23	0.00	8.76	0.00
WIDE SINGLE FIN	(0.375)	5.51	0.66	6.13	0.13	6.89	0.14	7.42	0.20	7.65	0.00						
DOUBLE PARALLEL FINS	(0.375)	4.23	0.35	5.22	0.39	5.78	0.15										
DOUBLE CONVERGING FINS	(0.375)	3.73	0.39	4.91	0.50	5.67	0.49	5.73	0.00								
DOUBLE BRACED FINS	(0.375)	3.91	0.36	4.88	0.39	5.66	0.34	6.06	0.06								
OAK RIDGE FIN	(0.375)	3.96	0.28	5.12	0.23	5.84	0.11	6.35	0.13								

ALL FIN TYPES WITH A 0.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 10.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVL	STD DEV
WIDE SINGLE FIN	(0.250)	4.39	0.65	5.49	0.60	5.96	0.24	6.49	0.32								
DOUBLE PARALLEL FINS	(0.250)	2.10	2.60	2.40	1.68	4.20	0.80	4.22	0.21	4.87	0.47	5.29	0.48	6.31	0.74	6.73	0.59
DOUBLE CONVERGING FINS	(0.250)	5.31	0.28	6.14	0.23	6.80	0.22	7.35	0.19	8.04	0.17	9.09	0.16				
DOUBLE BRACED FINS	(0.250)	5.04	0.16	6.12	0.29	6.90	0.36	7.48	0.40	8.11	0.44	8.61	0.31				
OAK RIDGE FIN	(0.250)	2.78	0.14	3.62	0.13	3.97	0.13	4.22	0.10	4.41	0.09	4.58	0.07	4.99	0.18	5.42	0.53
WIDE SINGLE FIN	(0.375)	5.00	0.11	5.89	0.08	6.61	0.12	7.16	0.12	7.54	0.09						
DOUBLE PARALLEL FINS	(0.375)	4.69	0.24	5.62	0.30	6.37	0.36	6.66	0.08								
DOUBLE CONVERGING FINS	(0.375)	4.65	0.48	5.78	0.71	6.28	0.60	6.38	0.55	6.44	0.00	6.95	0.00				
DOUBLE BRACED FINS	(0.375)	4.37	0.30	5.30	0.33	6.00	0.35	6.58	0.38	6.67	0.12						
OAK RIDGE FIN	(0.375)	4.38	0.31	5.15	0.25	5.71	0.30	6.20	0.27	6.32	0.00	6.54	0.00				

ALL FIN TYPES WITH A 10.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 3.5 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)	5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN (0.250)	3.56	0.16	4.27	0.21	4.95	0.43	5.37	0.63	5.80	0.66	6.11	0.66	6.62	0.65	6.58	0.10
DOUBLE PARALLEL FINS (0.250)	3.59	0.35	4.83	0.57	5.63	0.87	6.60	0.67	7.34	0.99	7.98	0.90	9.17	1.07	10.22	1.24
WIDE SINGLE FIN (0.375)	2.44	0.07	3.69	0.52	3.72	0.55	4.53	0.59	5.21	0.52	5.36	0.65	5.64	0.47	6.06	0.43
DOUBLE PARALLEL FINS (0.375)	1.87	0.08	2.29	0.13	3.19	0.28	3.69	0.33	4.38	0.38	4.91	0.41	5.52	0.49	5.61	0.05

ALL FIN TYPES WITH A 10.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 4.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)	5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN (0.250)	3.93	0.26	4.26	0.59	5.06	0.54	5.66	0.68	5.83	0.33	6.18	0.39	6.33	0.02	6.70	0.01
DOUBLE PARALLEL FINS (0.250)	3.46	0.77	3.64	1.27	4.80	1.67	5.64	1.90	6.26	2.12	6.27	2.23	5.92	1.95	6.35	2.17
WIDE SINGLE FIN (0.375)																
DOUBLE PARALLEL FINS (0.375)	2.29	0.49	2.48	0.88	3.20	1.00	3.68	1.18	3.79	0.20	4.26	0.22	4.86	0.28	5.31	0.32

ALL FIN TYPES WITH A 10.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 6.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN	(0.250)	3.03	0.54	2.51	0.48	3.35	0.35	3.89	0.26	4.15	0.28	4.31	0.37	4.42	0.27	4.09	0.02
DOUBLE PARALLEL FINS	(0.250)	2.71	0.58	2.70	1.03	3.45	0.90	3.48	0.36	3.51	0.64	3.70	0.55	3.95	0.50	4.12	0.57
WIDE SINGLE FIN	(0.375)	3.20	0.00	2.84	0.00	2.52	0.00	3.47	0.00	3.67	0.00	3.72	0.00	4.09	0.00	4.49	0.00
DOUBLE PARALLEL FINS	(0.375)	2.15	0.30	1.86	0.28	2.67	0.33	3.38	0.35	4.02	0.27	4.46	0.32	4.72	0.04		

ALL FIN TYPES WITH A 10.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 8.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN	(0.250)	3.22	0.81	3.91	0.65	4.10	0.21	4.30	0.30	4.49	0.30	4.64	0.33	4.88	0.33	5.07	0.32
DOUBLE PARALLEL FINS	(0.250)	3.19	0.62	3.54	0.85	4.26	0.54	4.95	0.38	5.41	0.40	5.67	0.43	6.23	0.65	6.78	0.74
WIDE SINGLE FIN	(0.375)																
DOUBLE PARALLEL FINS	(0.375)	1.63	0.26	1.97	0.37	2.21	0.62	2.44	0.80	2.59	0.94	2.73	1.06	2.49	0.68	2.66	0.71

ALL FIN TYPES WITH A 10.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 10.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN	(0.250)	2.78	0.83	3.22	0.81	3.60	0.97	3.54	1.04	3.52	1.26	2.71	0.00	2.97	0.00	3.71	0.00
DOUBLE PARALLEL FINS	(0.250)	2.38	0.20	3.12	0.51	3.98	0.73	4.64	0.63	4.96	0.70	5.23	0.75	5.36	0.58	5.49	0.37
WIDE SINGLE FIN	(0.375)	4.17	0.39	4.11	0.96	3.82	0.47	4.15	0.42	4.32	0.39	4.49	0.38	4.68	0.37	4.83	0.40
DOUBLE PARALLEL FINS	(0.375)	2.26	0.53	2.57	0.52	3.16	0.57	3.75	0.40	4.04	0.33	4.24	0.28				

ALL FIN TYPES WITH A 20.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 3.5 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)	5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
	GROUP	STD	GROUP	STD	GROUP	STD	GROUP	STD	GROUP	STD	GROUP	STD	GROUP	STD	GROUP	STD
WIDE SINGLE FIN (0.250)	0.55	0.04	1.19	0.16	1.75	0.45	2.27	0.48	2.55	0.43	2.85	0.43	3.05	0.26	3.26	0.20
DOUBLE PARALLEL FINS (0.250)	0.45	0.04	0.96	0.16	1.52	0.40	2.29	0.60	2.45	0.00	2.89	0.00				
WIDE SINGLE FIN (0.375)																
DOUBLE PARALLEL FINS (0.375)	0.43	0.09	1.12	0.18	1.73	0.25	2.21	0.29	2.71	0.36	3.04	0.41	3.09	0.06	3.49	0.03

ALL FIN TYPES WITH A 20.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 4.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN	(0.250)	0.67	0.03	0.91	0.04	1.44	0.09	1.99	0.10	2.45	0.08	2.70	0.07	3.21	0.03		
DOUBLE PARALLEL FINS	(0.250)	0.61	0.12	1.30	0.35	1.84	0.37	2.50	0.48	2.72	0.30	3.02	0.40	3.18	0.00	3.55	0.00
WIDE SINGLE FIN	(0.375)																
DOUBLE PARALLEL FINS	(0.375)	0.59	0.11	1.11	0.18	1.70	0.34	2.20	0.44	2.48	0.56	2.76	0.63	3.19	0.71	2.99	0.72

ALL FIN TYPES WITH A 20.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 6.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN	(0.250)	0.81	0.01	0.99	0.24	1.32	0.25	1.56	0.30	1.75	0.33	1.90	0.34	2.04	0.24	2.15	0.05
DOUBLE PARALLEL FINS	(0.250)	0.85	0.12	1.36	0.31	2.02	0.53	2.67	0.53	3.30	0.64	3.78	0.59	4.24	0.47	4.46	0.46
WIDE SINGLE FIN	(0.375)																
DOUBLE PARALLEL FINS	(0.375)	0.60	0.03	1.21	0.10	1.66	0.19	2.24	0.23	2.58	0.24	2.91	0.27	3.50	0.31	3.82	0.24

ALL FIN TYPES WITH A 20.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 8.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)	5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN (0.250)	0.41	0.08	0.62	0.06	0.83	0.07	0.99	0.06	1.14	0.06	1.27	0.06				
DOUBLE PARALLEL FINS (0.250)	0.56	0.26	2.06	0.31	2.99	0.52	3.32	0.65	3.25	0.27	3.45	0.26	3.54	0.00		
WIDE SINGLE FIN (0 375)	0.68	0.05	1.42	0.17	1.96	0.47	2.32	0.63	2.60	0.70	2.80	0.70	2.75	0.00		
DOUBLE PARALLEL FINS (0.375)	0.59	0.04	1.16	0.07	1.87	0.10	2.54	0.09								

ALL FIN TYPES WITH A 20.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 10.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)	5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN (0.250)	0.31	0.03	0.53	0.03	0.72	0.04	0.87	0.05	1.00	0.05	1.09	0.01				
DOUBLE PARALLEL FINS (0.250)	0.75	0.18	2.12	0.35	2.46	0.44	2.70	0.42	2.39	0.00	2.50	0.00	2.67	0.00		
WIDE SINGLE FIN (0.375)	0.71	0.18	1.54	0.60	1.87	0.43	2.09	0.51	2.05	0.38	2.16	0.39	2.45	0.39	2.23	0.00
DOUBLE PARALLEL FINS (0.375)	0.61	0.11	1.05	0.31	1.08	0.01	1.21	0.00	1.33	0.00	1.44	0.00				

ALL FIN TYPES WITH A 30.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 3.5 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN	(0.250)	0.23	0.03	0.55	0.02	0.66	0.03	1.00	0.05	1.16	0.07	1.43	0.07	1.75	0.05	2.03	0.05
DOUBLE PARALLEL FINS	(0.250)	0.29	0.03	0.65	0.04	1.19	0.05	1.70	0.06	2.12	0.08	2.30	0.00				
OAK RIDGE FIN	(0.250)	0.28	0.07	0.39	0.04	0.57	0.05	0.75	0.07	0.88	0.07	0.99	0.06	1.22	0.06	1.44	0.07
WIDE SINGLE FIN	(0.375)	0.22	0.09	0.55	0.07	0.88	0.05	1.24	0.05	1.51	0.06	1.60	0.10	1.98	0.11	2.17	0.00
DOUBLE PARALLEL FINS	(0.375)	0.44	0.11	0.81	0.09	1.17	0.10	1.51	0.09								
OAK RIDGE FIN	(0.375)	0.30	0.01	0.52	0.05	0.76	0.09	1.01	0.09	1.22	0.11	1.27	0.04				

ALL FIN TYPES WITH A 30.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 4.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)	5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN (0.250)	0.26	0.04	0.55	0.03	0.84	0.07	1.12	0.09	1.31	0.09	1.49	0.06	1.80	0.06	2.07	0.05
DOUBLE PARALLEL FINS (0.250)	0.18	0.10	0.57	0.14	0.93	0.17	1.31	0.22	1.56	0.24	1.73	0.28	2.02	0.33	2.27	0.38
OAK RIDGE FIN (0.250)	0.29	0.05	0.44	0.05	0.57	0.04	0.71	0.04	0.84	0.04	0.97	0.04	1.20	0.05	1.41	0.05
WIDE SINGLE FIN (0.375)	0.23	0.12	0.52	0.12	0.79	0.21	1.05	0.28	1.24	0.33	1.41	0.37	1.46	0.29	1.55	0.14
DOUBLE PARALLEL FINS (0.375)	0.33	0.08	0.81	0.11	1.22	0.15	1.47	0.16	1.49	0.00						
OAK RIDGE FIN (0.375)	0.26	0.08	0.57	0.17	0.81	0.21	0.96	0.21	1.11	0.21	1.21	0.20	1.20	0.00		

ALL FIN TYPES WITH A 30.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 6.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN	(0.250)	0.36	0.30	0.54	0.34	0.74	0.46	0.66	0.21	0.76	0.25	0.86	0.30	1.05	0.39	1.02	0.49
DOUBLE PARALLEL FINS	(0.250)	0.37	0.05	0.73	0.10	1.05	0.14	1.49	0.20	1.93	0.25	2.28	0.26	2.70	0.22	2.91	0.21
OAK RIDGE FIN	(0.250)	0.24	0.06	0.44	0.10	0.57	0.10	0.69	0.11	0.79	0.09	0.90	0.09	1.09	0.09	1.27	0.09
WIDE SINGLE FIN	(0.375)	0.23	0.11	0.32	0.04	0.51	0.05	0.63	0.08	0.76	0.08	0.88	0.08	1.09	0.11	1.28	0.16
DOUBLE PARALLEL FINS	(0.375)	0.33	0.10	0.68	0.04	0.92	0.05	1.09	0.08	1.21	0.09	1.32	0.09				
OAK RIDGE FIN	(0.375)	0.18	0.01	0.36	0.02	0.52	0.03	0.65	0.03	0.77	0.04	0.88	0.04	1.10	0.04	1.30	0.04

ALL FIN TYPES WITH A 30.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 8.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN	(0.250)	0.16	0.02	0.38	0.06	0.50	0.05	0.63	0.05	0.74	0.05	0.85	0.05	1.05	0.04		
DOUBLE PARALLEL FINS	(0.250)	0.17	0.06	0.82	0.12	1.24	0.16	1.40	0.16	1.53	0.15	1.63	0.15	1.76	0.06		
OAK RIDGE FIN	(0.250)	0.20	0.07	0.30	0.04	0.41	0.04	0.51	0.04	0.61	0.04	0.70	0.05	0.85	0.05	1.00	0.06
WIDE SINGLE FIN	(0.375)	0.33	0.06	0.45	0.09	0.59	0.11	0.71	0.13	0.82	0.15	0.93	0.17	1.10	0.23	1.29	0.28
DOUBLE PARALLEL FINS	(0.375)	0.22	0.06	0.39	0.06	0.55	0.08	0.68	0.10	0.80	0.13	0.92	0.16	1.03	0.01	1.21	0.01
OAK RIDGE FIN	(0.375)	0.21	0.04	0.32	0.02	0.47	0.02	0.59	0.02	0.70	0.02	0.80	0.02	0.99	0.02	1.16	0.01

ALL FIN TYPES WITH A 30.0 DEGREE ANGLE OF INCLINATION AND

FIN LENGTH = 10.0 (inches)

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS)		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
WIDE SINGLE FIN	(0.250)	0.11	0.03	0.26	0.03	0.39	0.04	0.51	0.05	0.62	0.06	0.71	0.06	0.87	0.04		
DOUBLE PARALLEL FINS	(0.250)	0.16	0.02	0.53	0.09	0.72	0.09	0.85	0.08	0.95	0.14	1.15	0.00	1.32	0.00	1.48	0.00
OAK RIDGE FIN	(0.250)	0.16	0.07	0.28	0.06	0.39	0.06	0.50	0.06	0.59	0.06	0.68	0.07	0.81	0.05	0.71	0.04
WIDE SINGLE FIN	(0.375)	0.25	0.04	0.33	0.09	0.42	0.12	0.52	0.16	0.63	0.20	0.71	0.24	0.90	0.33	0.90	0.18
DOUBLE PARALLEL FINS	(0.375)	0.16	0.06	0.29	0.06	0.42	0.08	0.54	0.10	0.65	0.11	0.75	0.13	0.83	0.00	0.79	0.00
OAK RIDGE FIN	(0.375)	0.20	0.05	0.33	0.06	0.44	0.06	0.55	0.06	0.64	0.05	0.70	0.01	0.87	0.01	1.02	0.01

CENTRE FIN HAS A 0.0 DEGREE ANGLE OF INCLINATION. AND THE OTHER TWO EACH HAVE A 15.0 DEGREE ANGLE OF INCLINATION

ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (FROM LOAD CELL DATA)

FIN SPECIMEN TYPE & (THICKNESS) & [FIN LENGTH]		5 %		10 %		15 %		20 %		25 %		30 %		40 %		50 %	
		GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV	GROUP AVE	STD DEV
TRIPLE FINS [3.5" long]	(0.250)	2.19	0.17	3.10	0.29	4.17	0.39	4.76	0.45	5.56	0.45	6.08	0.51	6.97	0.46	8.18	0.44
TRIPLE FINS	(0.375)	1.65	0.08	2.93	0.21	4.06	0.31	5.00	0.41	5.59	0.22						
TRIPLE FINS [4" long]	(0.250)	2.50	0.23	2.87	0.37	3.90	0.38	4.31	0.43	4.96	0.37	5.48	0.38	6.28	0.32	7.29	0.15
TRIPLE FINS	(0.375)	1.73	0.06	2.81	0.23	3.67	0.32	4.42	0.35	5.11	0.41	5.35	0.33	5.74	<.01		
TRIPLE FINS [6" long]	(0.250)	2.76	0.40	2.82	0.48	3.75	0.39	4.59	0.45	5.29	0.53	5.75	0.51	6.65	0.55	7.20	0.57
TRIPLE FINS	(0.375)	1.79	0.09	2.45	0.12	3.03	0.13	3.60	0.15	4.22	0.16	4.66	0.18				
TRIPLE FINS [8" long]	(0.250)	2.96	0.16	3.72	0.27	4.77	0.40	5.65	0.44	6.19	0.52	6.65	0.47	7.26	0.10	7.09	0.05
TRIPLE FINS	(0.375)	2.16	0.14	2.82	0.42	3.68	0.57	4.11	0.72	4.10	0.50	4.40	0.57	4.72	<.01		
TRIPLE FINS [10" long]	(0.250)	2.54	0.29	2.99	0.15	3.38	0.23	3.73	0.24	4.15	0.35	4.55	0.41	5.15	0.34	5.61	0.27
TRIPLE FINS	(0.375)	2.14	0.19	2.36	0.21	3.06	0.40	3.37	0.50	3.28	0.20	3.44	0.23	3.87	0.15		

APPENDIX A

DESCRIPTION OF THE DROP TOWER FACILITY

A.1 Description of the Drop Tower Facility

The Monserco drop test facility, shown in Figure A1, has a maximum drop height of 30 feet (9 m) and a maximum hammer weight of 1000 lb (455 kg). The tower structure comprises two 5 inch square section steel columns mounted on a rigid base and braced against an adjacent building wall. Rails welded on the inner surfaces of the tower structure guide the hammers' ascent and descent.

The base of the facility is both rigid and massive. It consists of a 1.5 inch (38 mm) thick mild steel plate bolted onto a steel box filled with 16000 lbs (7300 kg) of concrete and reinforcing bar. The box is buried in the ground so that the impact surface is just above grade level.

The hammer, shown in Figure A2, has a face made from 1 inch (25 mm) thick steel plate, machined flat and smooth. Attached to the top of the hammer face is a rectangular frame which houses the guide rollers and the hoisting attachment. To keep the minimum weight of the hammer as low as practical, two hammer faces were made, one smaller and lighter face for the 2 inch (51 mm) wide fin specimens, and one larger face for the 10 inch (254 mm) wide fins. The hammer was designed so that the faces could be changed easily, simply by unbolting the frame which was attached by four cap screws. However towards the end of the testing while testing some of the more rigid inclined fin specimens, it became necessary to weld the frame to the hammer plate as the cap screws began to yield and fail when the hammer impacted the test specimen.

The minimum hammer weight was 100 lbs (45 kg) with the smaller hammer face and 165 lbs (75 kg) with the larger hammer face. The hammer weight could be increased in 40 lb (18 kg) increments by adding weights that were fabricated from 1 inch (25 mm) thick plate. These were firmly secured to the hammer by two studs that bolted into the back of the face inside the rectangular frame section. A maximum of 10 weights could be accomodated.

A quick release hook was attached to the hoist chain to facilitate easy release of the hammer from the desired test height. A slight tug on the "trigger" rope was sufficient to release the hammer.

Figure A3 shows the fin specimen holder. This served to locate the specimen in the centre of the hammer and to prevent it from flying loose during impact. To change specimens it was necessary to release the cap screws on only one side of the holder.

A.2 Instrumentation

The response of the deforming fins during impact was measured by two means:

i) a load cell fixed directly below the specimen holder, and
ii) an accelerometer fixed into the upper (back) surface of the hammer.

A.2.1 Load Cell

As in the ORNL experiments, it was necessary to make three load cells of different sensitivities to accurately measure the impact forces for the entire range of fin specimens. These were essentially the same design as those used at ORNL, only the dimensions were slightly different. The load cells were cylinders each 10 inches (254 mm) long and the same internal diameter of 5.5 inches (65 mm). The outside diameters of the three cells were 5.704 inches (144.88 mm), 6.156 inches (156.36 mm) and 7.832 inches (199.93 mm) respectively. The load cells were fabricated from carbon steel hollow bar stock.

Ninety-degree Tee-rosette strain gauges were bonded to the outer circumference of the cylinders and connected in a four-active-arm Wheatstone bridge arrangement, two gauges in each arm, illustrated in Figure A4. This is the same arrangement used by ORNL. Bridge power supply and output signal amplification was provided by a Honeywell Accudate 218 Bridge amplifier. Although the output from the load cells was readily measurable, noise on the bridge signal induced by a nearby radio station was a problem and necessitated some amplification.

A.2.2 Accelerometer

To obtain acceleration-time data during impact, a piezoelectric accelerometer was attached to the centre of the back face of the hammer. Two different accelerometers were used during testing to cover the expected peak signal range; one having a full-scale range of 500 g and 10 mV/g sensitivity, and the other having a 5000 g full-scale range and 1 mV/g sensitivity. The calibration certificates for the accelerometers are included in Appendix B.

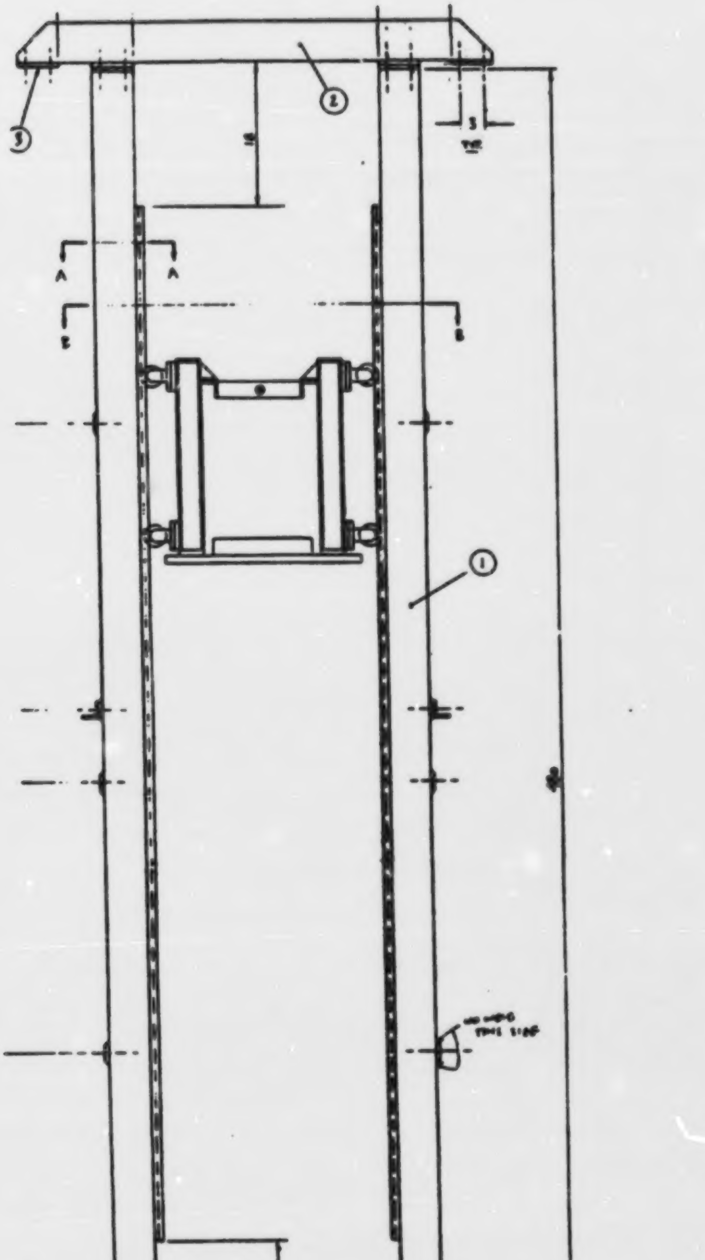


FIGURE A1
DROP TEST FACILITY

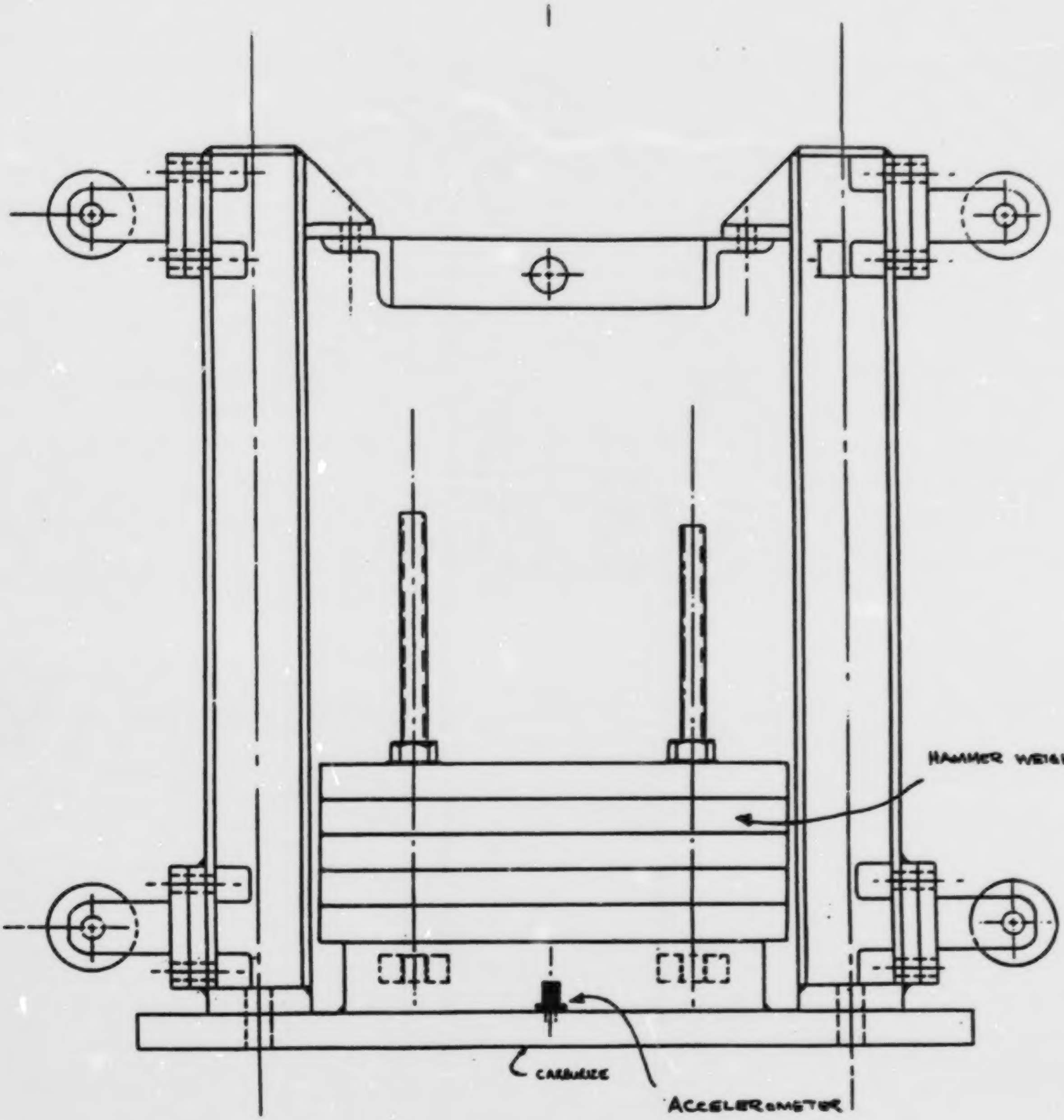

HAMMER WEIGHTS
CARBURIZE
ACCELEROMETER

FIGURE A2

DROP HAMMER ARRANGEMENT

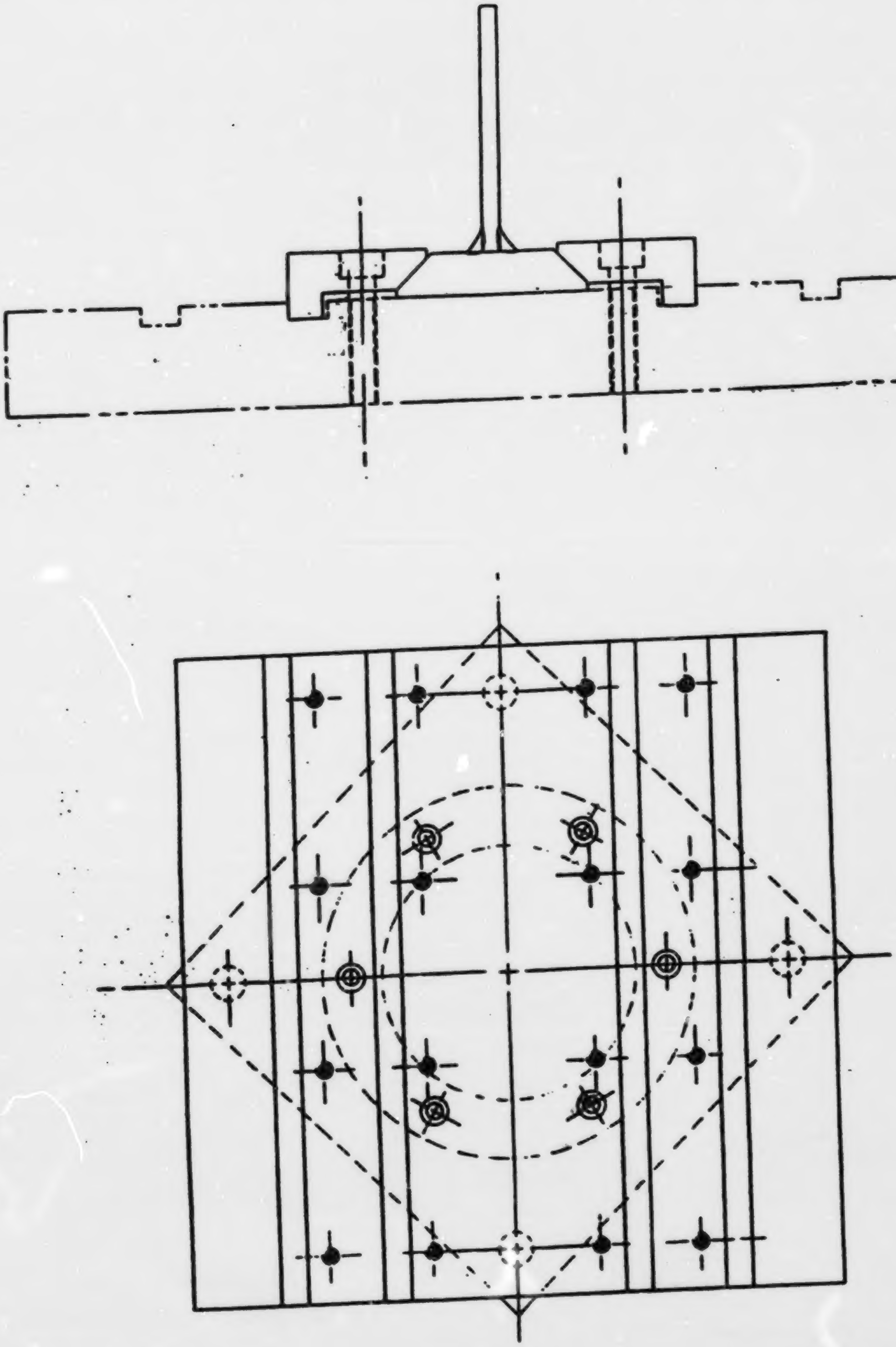


FIGURE A3
FIN SPECIMEN HOLDER

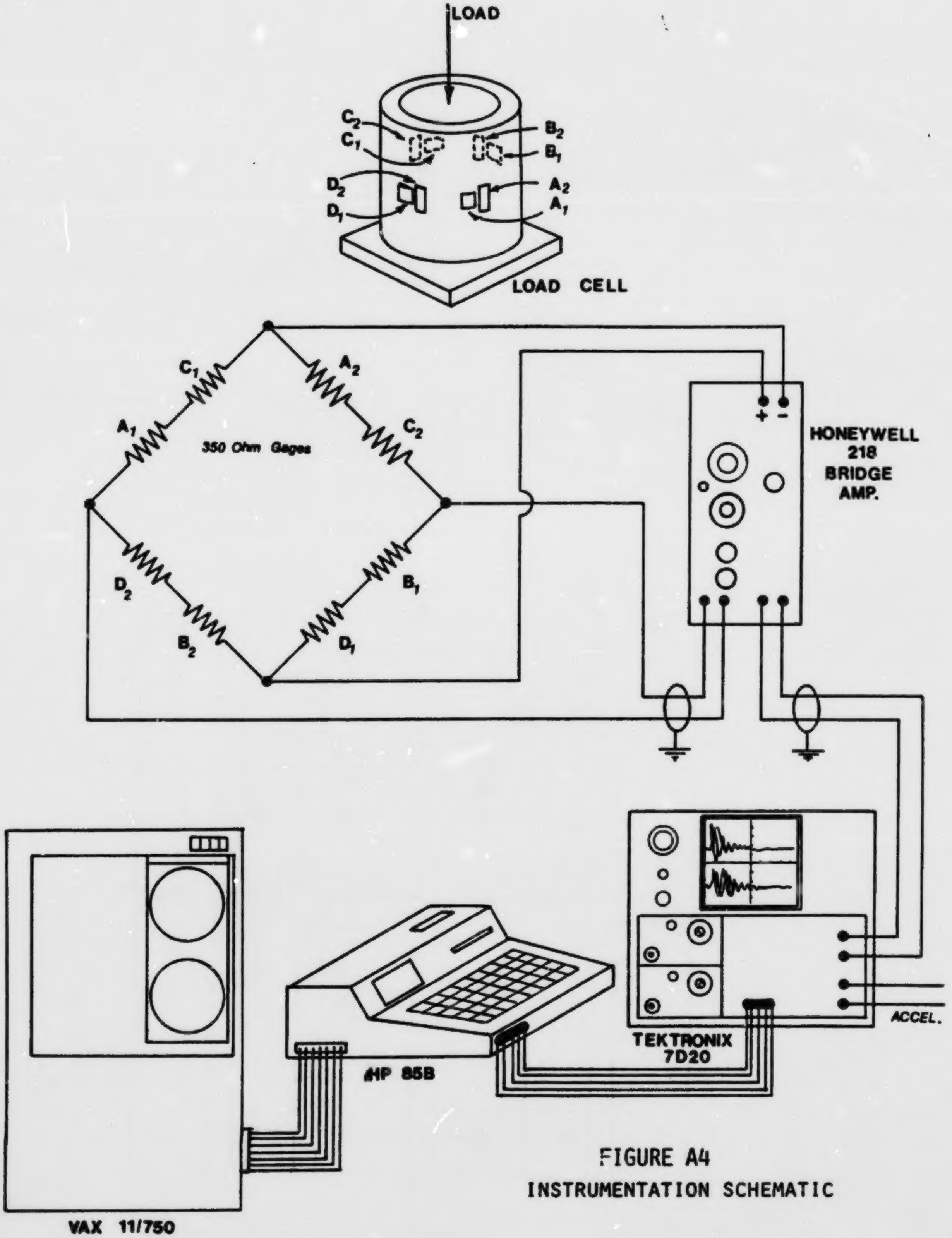

LOAD
C2
C1
B2
B1
D2
D1
A2
A1
LOAD CELL
C1
A2
A1
C2
350 Ohm Gages
D2
B1
B2
D1
+
-
HONEYWELL 218 BRIDGE AMP.
TEKTRONIX 7D20
ACCEL.
HP 85B
VAX 11/750

FIGURE A4
INSTRUMENTATION SCHEMATIC

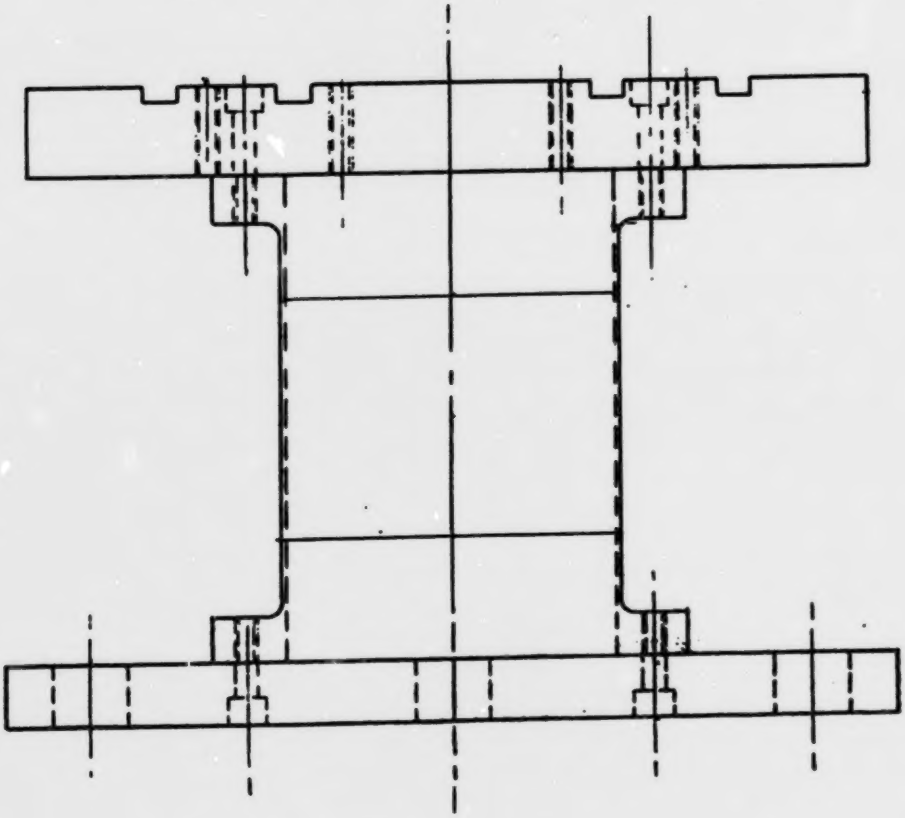


FIGURE A5
LOAD CELL ARRANGEMENT

APPENDIX B

CALIBRATION DATA FOR LOAD CELLS AND ACCELEROMETERS

B.1 Calibration Data for Load Cells and Accelerometers

The three load cells were calibrated using a Baldwin 400,000 lb Universal testing machine of the Ontario Research Foundation. Each load cell was calibrated separately by loading it up to a maximum level at a controlled rate and then unloading it, stopping at regular intervals to take readings of strain gauge bridge output. The procedure was repeated twice for each cell. The maximum loading for the three load cells was 35,000 lb. (15,900 kg), 150,000 lb (68,180 kg) and 390,000 lb (177,270 kg) respectively. Bridge output readings were taken from the same bridge amplifier used in the experimental tests.

Load cell calibration was done on the 23 Feb. 1984 while the testing machine was last calibrated on the 18 July 1983.

The calibration curves are presented in Figures B-1, B-2 and B-3. It should be explained here that when the load cells were calibrated, the bridge amplifier was set up to give a full-scale output of 5 volts. However, for drop testing the amplification factor was double so that the maximum bridge output was 10 volts. Therefore the load cell calibration factors shown on the calibration curves were multiplied by two when calculating the loads from the test data.

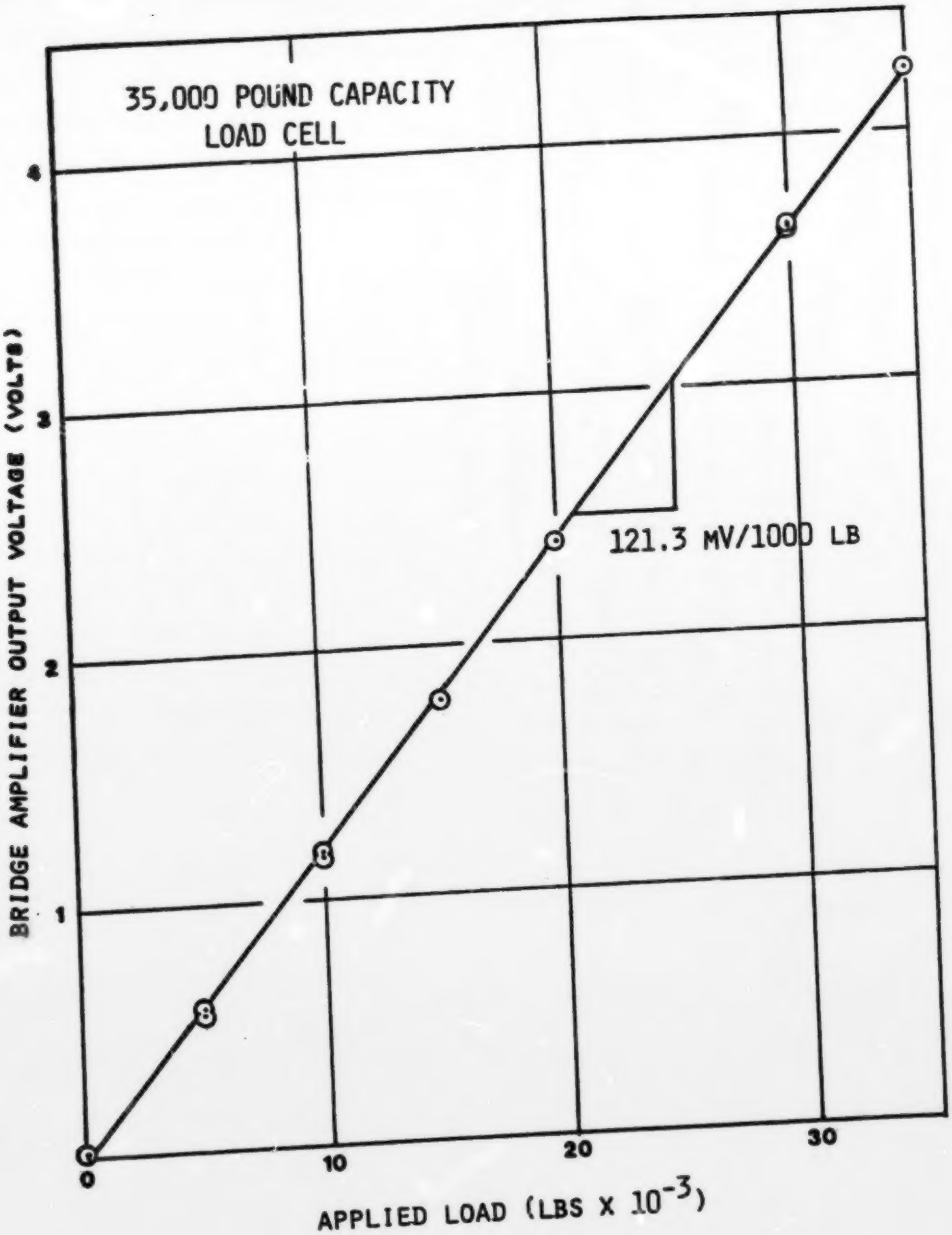


FIGURE B1 - CALIBRATION CURVE FOR 35000 LB LOAD CELL

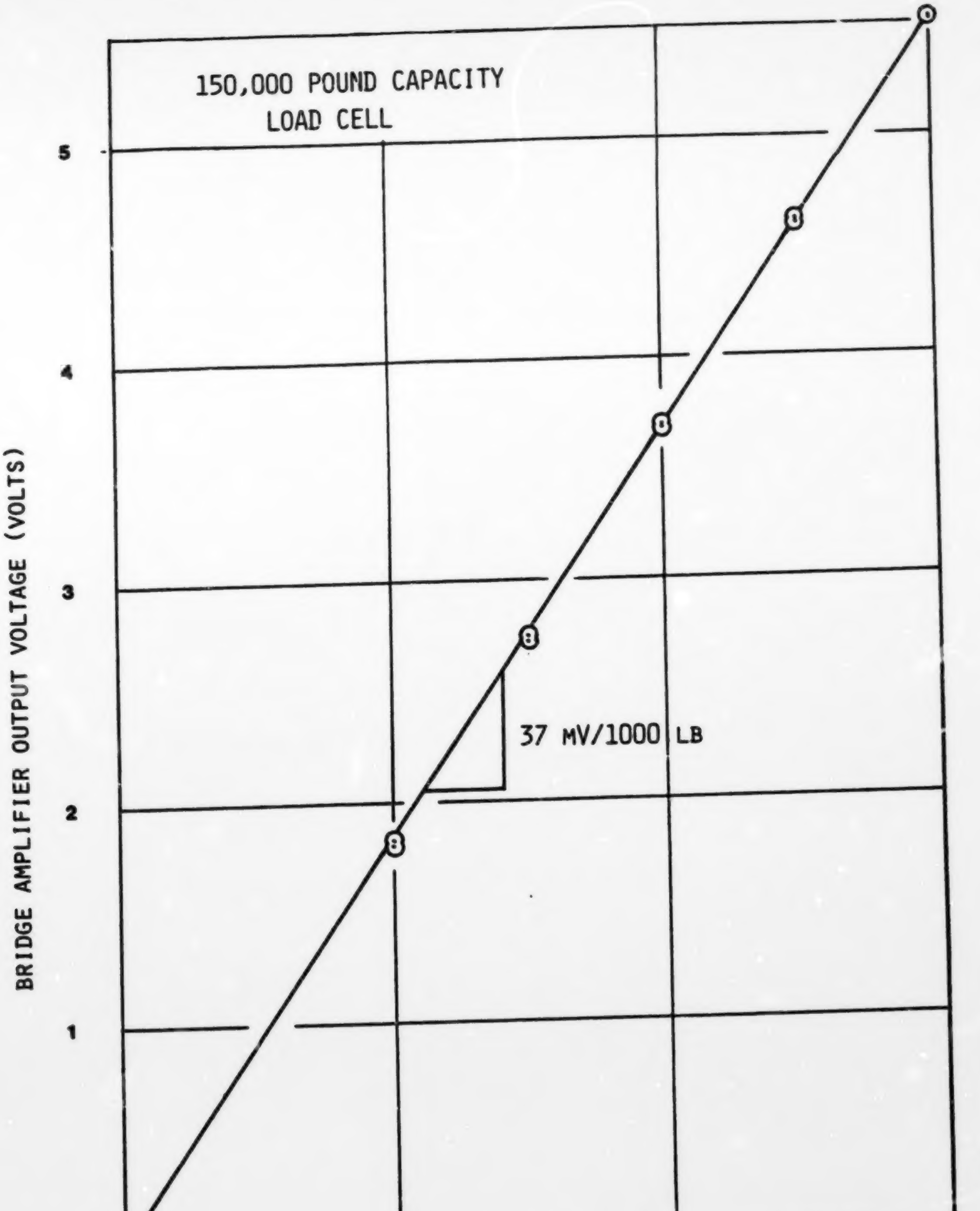


FIGURE B2 - CALIBRATION CURVE FOR 150000 LB LOAD CELL

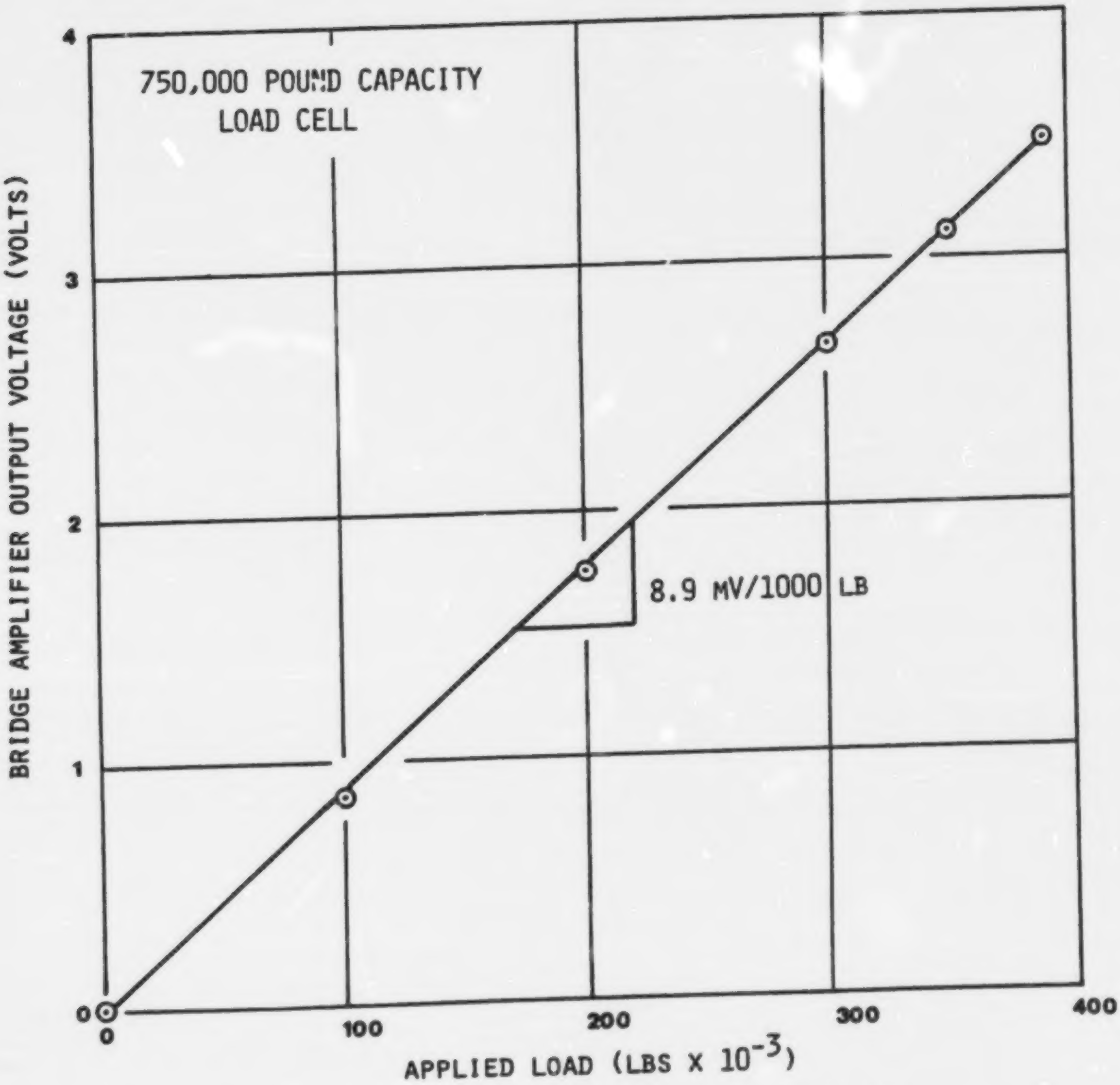


FIGURE B3 - CALIBRATION CURVE FOR 750000 LB LOAD CELL

DURHAM INSTRUMENTS
DIVISION OF DURHAM INSTRUMENTS, INC.
P. O. BOX 426
PICKERING, ONTARIO L1V 2R7.

DYTRAN INSTRUMENTS INC.

Dynamic Transducers and Systems

8523 Canoga Ave Unit H
Canoga Park, CA. 91304
(213) 700-7318

CALIBRATION CERTIFICATE
PIEZOELECTRIC ACCELEROMETER
LOW IMPEDANCE, VOLTAGE MODE (LIVM)

MODEL 3200A5T RANGE, F.S 5000 G

S/N 188 NOMINAL SENSITIVITY 1.0 mV/g

F.S. OUTPUT VOLTAGE 5.0 VOLTS, NOMINAL

MEASURED SENSITIVITY @ 5000 G LEVEL

0.90 mV/g

RESONANT FREQUENCY, MOUNTED 120 kHz

BIAS VOLTAGE 10.4 VOLTS, DC

THIS CALIBRATION TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS

LABORATORY NO. 232.09/209275

CUSTOMER Durham Instruments INVOICE NO 81403

ORDER NO: 3428A DATE: 12/30/83

CALIBRATION PERFORMED BY: John S. Kantor

DURHAM INSTRUMENTS
DIVISION OF TUCHAN INSTRUMENTS, INC.
P. O. BOX [illegible]
PICKERING, ONTARIO L1V 2R7

DYTRAN INSTRUMENTS INC.

Dynamic Transducers and Systems

8523 H Canoga Ave.
Canoga Park, CA 9[illegible]
(213) 700-7815

CALIBRATION CERTIFICATE

VOLTAGE MODE ACCELEROMETER

MODEL 3101A NOMINAL SENSITIVITY 10.0 mV/g

SERIAL NO. 245 RANGE, F.S. 500 g

REFERENCE SENSITIVITY MEASURED AT 100 Hz, 1g RMS 10.2 mV/g

FREQUENCY RESPONSE [1]

FREQUENCY (Hz)	SENSITIVITY DEVIATION (mV/g)
20	9.7
30	10.3
50	10.1
100	10.2
300	10.1
500	10.1
1000	10.1
3000	10.2
5000	10.2
8000	10.3
10000	9.9
12000	9.9

MAXIMUM TRANSVERSE SENSITIVITY 3.0 %

BIAS VOLTAGE 12.7 V

DISCHARGE TIME CONSTANT 7.5 sec

[1] This calibration was performed using the back to back comparison method per ISA S37.2. This calibration is traceable to the N.B.S. test number 737/737001-83.

CUSTOMER: Durham Instruments INVOICE NO. 81403

ORDER NO: 3428A - DATE: 12/30/83

CALIBRATION PERFORMED BY:

APPENDIX C

COMPUTER CODE LISTING

```
C****************************************************************************
C
      SUBROUTINE FINCALC
*****************************************************************************
      INCLUDE 'FIN.CMN'
C
C  THIS SUBROUTINE CONVERTS THE LOADCELL AND ACCELEROMETER DATA FROM MILLIVOLTS
C  TO FORCE OR ACCELERATION AND THEN CALLS SUBROUTINE FINENGY TO DO THE ENERGY
C  COMPUTATION.  IT ALSO CALCULATES THE PLASTIC MOMENT FOR THE PARTICULAR FIN
C  CONFIGURATION AND THE RATIO OF ABSORBED ENERGY/PALASTIC MOMENT. THE PERCENT
C  DEFORMATION AND THE DEFORMATION FROM MEASUREMENTS.
C
      NPTS = 1024
C  *******************
C   LOAD CELL DATA :
C  *******************
C    IDENTIFY WHICH LOADCELL WAS USED AND SET THE SLOPE PARAMETER
      SLOPE = -8245.12*0.5                         ! 8245.12 by least sq fit
      IF (NLOADCELL .EQ. 2) SLOPE = -27060.48*0.5  ! 27060.48 by least sq fit

      IF (NLOADCELL .EQ. 3) SLOPE = -112294.31*0.5 ! 112294.31 by least sq fit
C  The 0.5 factor converts the scale factor for 10 volts max output from sg amp
C
C    CONVERT LOADCELL OUTPUT VOLTAGES TC FORCE- AND ACCELERATION-TIME DATA
      FPEAKL = 0.
      FMINL  = 0.
      DO 10 I=1,NPTS
      FF = (LOADCELL(I)*YMULT2) + YZERO2
      FL(I) = FF*SLOPE                        !Force from loadcell trace
      AL(I) = -FL(I)*32.2/HAMWT               !Accel derived from loadcell trace
      FPEAKL = AMAX1(FPEAKL,FL(I))            !Max load on loadcell
      FMINL  = MIN(FMINL,FL(I))               !Min load on loadcell
10    CONTINUE
C
      CALL FINENGY (AL,FL,UL,DEFL,TL,UMAXL,DEFMAXL)
C
C   **********************
C    ACCELEROMETER DATA:
C   **********************
C     IDENTIFY WHICH ACCELEROMETER WAS USED
      SENSIT = 10.0                         ! Accelratr # 1:  10 mv/g
      IF (NACCEL .EQ. 2) SENSIT = 1.0       ! Accelratr # 2:   1 mv/g
C
C   CONVERT ACCELEROMETER OUTPUT VOLTAGES TO FORCE- AND ACCEL-TIME DATA
      FPEAKA = 0.
      FMINA  = 0.
      DO 20 I=1,NPTS
      FF = (ACCEL(I)*YMULT1) + YZERO1
      AA(I) = -FF*SENSIT*32.2*1000.        !Accel from accelerometer trace
      FA(I) = -AA(I)*HAMWT/32.2            !Force derived from accelmtr trace
      FPEAKA = AMAX1(FPEAKA,FA(I))
      FMINA  = MIN(FMINA,FA(I))
20    CONTINUE
C
      CALL FINENGY (AA,FA,UA,DEFA,TA,UMAXA,DEFMAXA)
C
C      COMPUTE PLASTIC MOMENT FOR THE PARTICULAR FIN CONFIGURATION
      SIGMAY = 39860.
      IF (FINTK .EQ. 0.375) SIGMAY = 41380.
      MP = SIGMAY*0.25*FINL*FINTK**2
C
C
C    COMPUTE THE RATIO OF PEAK ABSORBED ENERGY/PLASTIC MOMENT AND
C    THE PERCENT DEFORMATION FROM BOTH SETS OF DATA
      FW = 1.                      !Equals 1 for single fin specimens.
      IF (ITYPE .GE. 2 .AND. ITYPE .LE. 5) FW = 2.  !2 for double fins
      IF (ITYPE .EQ. 3) FW = 3.                     !3 for triple fins
      UMPL = UMAXL/(MP*FW)                    !For peak energy absorbed
      UMPA = UMAXA/(MP*FW)                    !For peak energy absorbed
C
C      PERCENTAGE DEFORMATION (For peak deflection)
      HO = FINHT*COS(THETA/57.3)
      PDEFL = DEFMAXL/HO*100.
      PDEFA = DEFMAXA/HO*100.
C
C     COMPUTE THE PERCENT DEFORMATION FROM MEASUREMENT
      PDEFM = (HO - DEFHT)/HO*100.
      RETURN
      END
C
C
```

```
C*************************************************************************
C
      SUBROUTINE FINENGY (A,F,TOTU,TOTDEF,TIME,UMAX,DEFMAX)
**************************************************************************
      COMMON /DATA/ NPTS,IDATE,ITIME,DROPEL,HAMWT,DEFHT,NLOADCELL,
     1              NACCEL,DELTAT,ACCEL(1024),LOADCELL(1024),
     2              YMULT1,YMULT2,JSTART
C
C    THIS SUBROUTINE CALCULATES THE ENERGY ABSORBED BY THE FIN BY COMPUTING THE
C    AVERAGE ACCELERATION BETWEEN EACH DATA SAMPLING INTERVAL, THE DEFLECTION
C    DURING EACH TIME INTERVAL, AND HENCE THE ENERGY ABSORBED.
C    A FLAG IS SET AND THE TIME NOTED WHEN THE HAMMER VELOCITY FIRST REACHES
C    ZERO.
      DIMENSION A(1024),F(1024),DEF(1024),U(1024)
      TIME = 0.
      JFLAG = 0
      VO = SQRT(2.0*32.2*DROPEL/12. )                !Initial vel in ft/sec
      DEFMAX = 0.                                    !Max deformation
      UMAX = 0.                                      !Max energy
      DEF(JSTART) = 0.0                              !Initial deformation zero
      U(JSTART) = 0.0                                !Initl absorbed energy zero
C
      DO 20 J=JSTART+1,NPTS                        !Start integration at trigger pt
      ABAR = 0.5*(A(J-1) + A(J))                     !Ave accel over time int.
      VO = VO + ABAR*DELTAT                          !Ave vel over time int.
      DELTAX = (VO + 0.5*ABAR*DELTAT)*DELTAT*12.0    !Deflectn over time int.
      DEF(J) = DEF(J-1) + DELTAX                     !Accumulated deflection
      U(J) = U(J-1) + DELTAX*(F(J-1) + F(J))/2.0     !Energy absorbed in time int
C
      TOTU = U(J)                                  !Energy absorbed over whole time
      UMAX = AMAX1(UMAX,U(J))                      !Peak value of absorbed energy
      TOTDEF = DEF(J)                              !Deformatn over whole time
      DEFMAX = AMAX1(DEFMAX,DEF(J))                !Peak value of deformatn
C
C    CHECK IF THE VELOCITY AT THE START OF THE NEXT TIMESTEP HAS REACHED ZERO.
C    IF IT HAS, NOTE THE TIME AND SET THE FLAG SO THAT THIS TIME IS RETAINED.
      IF (VO .GT. 0.0 .OR. JFLAG .EQ. 1) GO TO 20
      TIME = (JSTART-J)*DELTAT
      JFLAG = 1
20    CONTINUE
C
C  If a printout of the computed results is required, remove the comment C's
C
C      WRITE (2,1000)                                !******
C      DO 40 J=1,NPTS                                !******
C      TIM = (J-1)*DELTAT                            !******
C      WRITE (2,1100) J,TIM,U(J),DEF(J),A(J),F(J)    !******
C40    CONTINUE                                      !******
      RETURN
C
C
1000  FORMAT ('1',5X,'#',19X,'TIME',T46,'ENGY',T65,'DEFMN'
     1,T95,'ACCEL',T105,'FORCE'///)
1100  FORMAT (' ',I10,10X,E10.3,4(10X,F10.3))
      END
C
C
```

APPENDIX D

PLOTS OF LOAD VS TIME
FOR EACH GROUP OF TEST SPECIMENS

Plots of Load vs Time, Absorbed Energy vs Time and the ratio of Measured to Calculated Deformation vs Time for each group of test specimens are included in the accompanying microfiches.

AN ASSESSMENT OF THE EFFECT THAT THE CUT-OFF FREQUENCY OF A LOW PASS FILTER HAS ON THE TRANSIENTS CAPTURED FROM A LOAD CELL

ADDENDUM REPORT INFO-0146

DECEMBER 1984

An Assessment of the Effect that the Cut-off Frequency of a Low Pass Filter has on the Transients Captured from a Load Cell

When capturing rapid transients from accelerometers, it is common to condition the output signal by first running it through a low pass filter. This removes the higher frequency components and smoothes out the transient, reducing the peak value of the transient. The purpose of this small side study was to make an assessment of the effect of cut-off frequency, not only on the peak values of a repeated impact transient, but also on the absorbed energy and hammer displacement, which are derived from the load cell transient. The load cell transient was used here, rather than the accelerometer transient, because the accelerometer output tended to show a zero shift - as explained in the main report - and this greatly affected the derived energy and displacement values.

The test specimens used for this study were 5.5 inch (140 mm) lengths of 5/8 inch (15.9 mm) threaded rod. These were screwed into a base plate that was clamped into the fin holder described in the main report. A lock nut held the rod specimen firmly in the base plate. A sketch of the rod holder is shown in Figure A.1. The same hammer weight and drop height was used for each of the specimens shown in Figure A.2.

The test was repeated fourteen times, with the low-pass filter cut-off frequency set at levels varying from 20 kH_z down to 20 H_z. The load cell transients that were obtained, and the absorbed energy deformation curves derived from those transients are shown in Figures A.3 to A.16. Values of peak load cell force and calculated absorbed energy are tabulated in Table A.1.

Figure A.17 shows how the peak load registered by the load cell is affected by the filter cut off frequency. Below 1 kH_z the effect is large, and above 5 kH_z there is not much effect.

In Figure A.18 the absorbed energy calculated from the load cell transients is plotted against filter cut-off frequency. This shows that the more the signal is smoothed out, the more closely the computed energy approaches the hammer potential energy.

These data thus support the ORNL contention that the accelerometer signal (used to calculate absorbed energy etc.) could be filtered, while the load cell signal (used to measure peak force) must be left unfiltered.

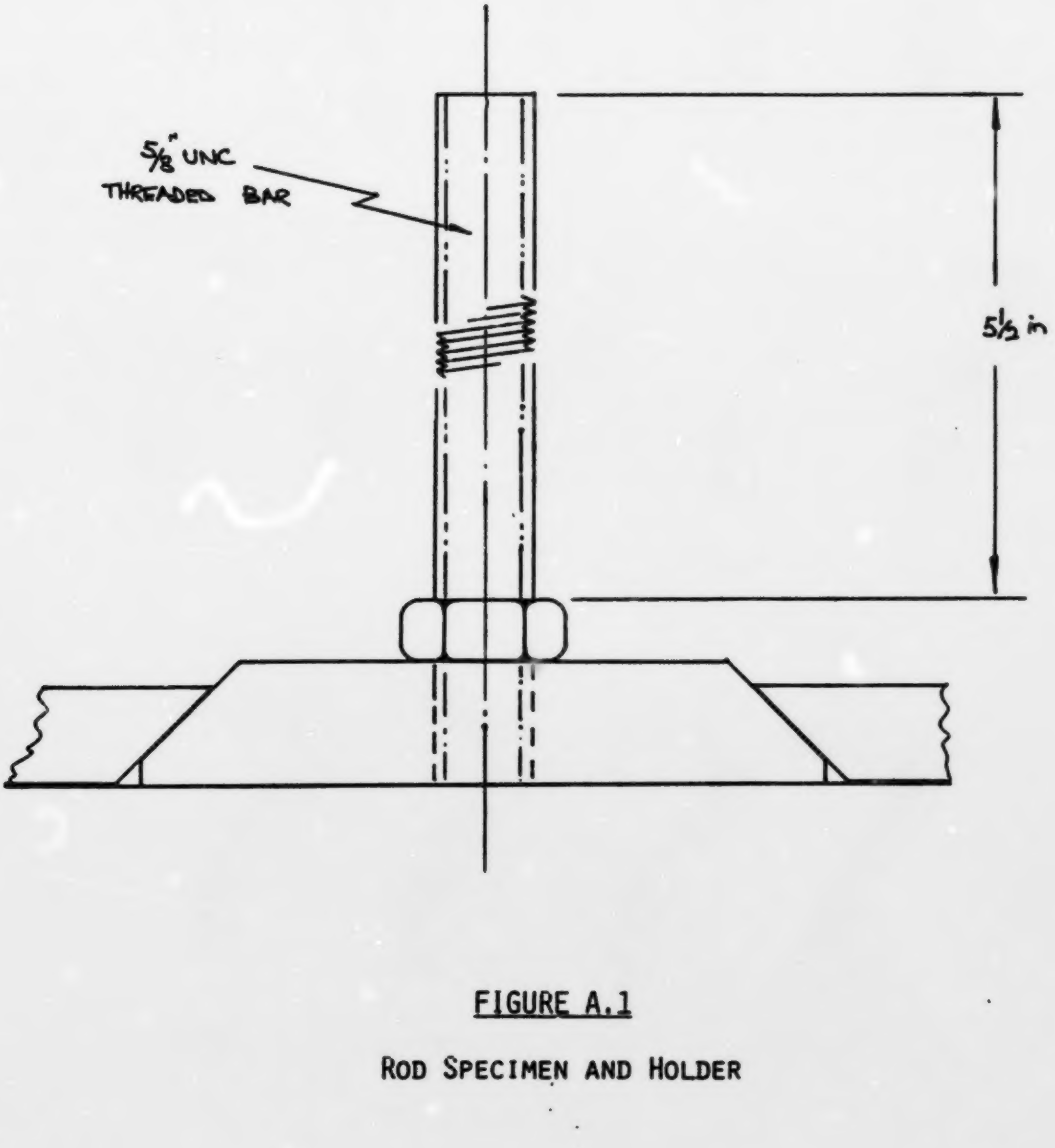

5/8" UNC
THREADED BAR
5½ in

FIGURE A.1

ROD SPECIMEN AND HOLDER

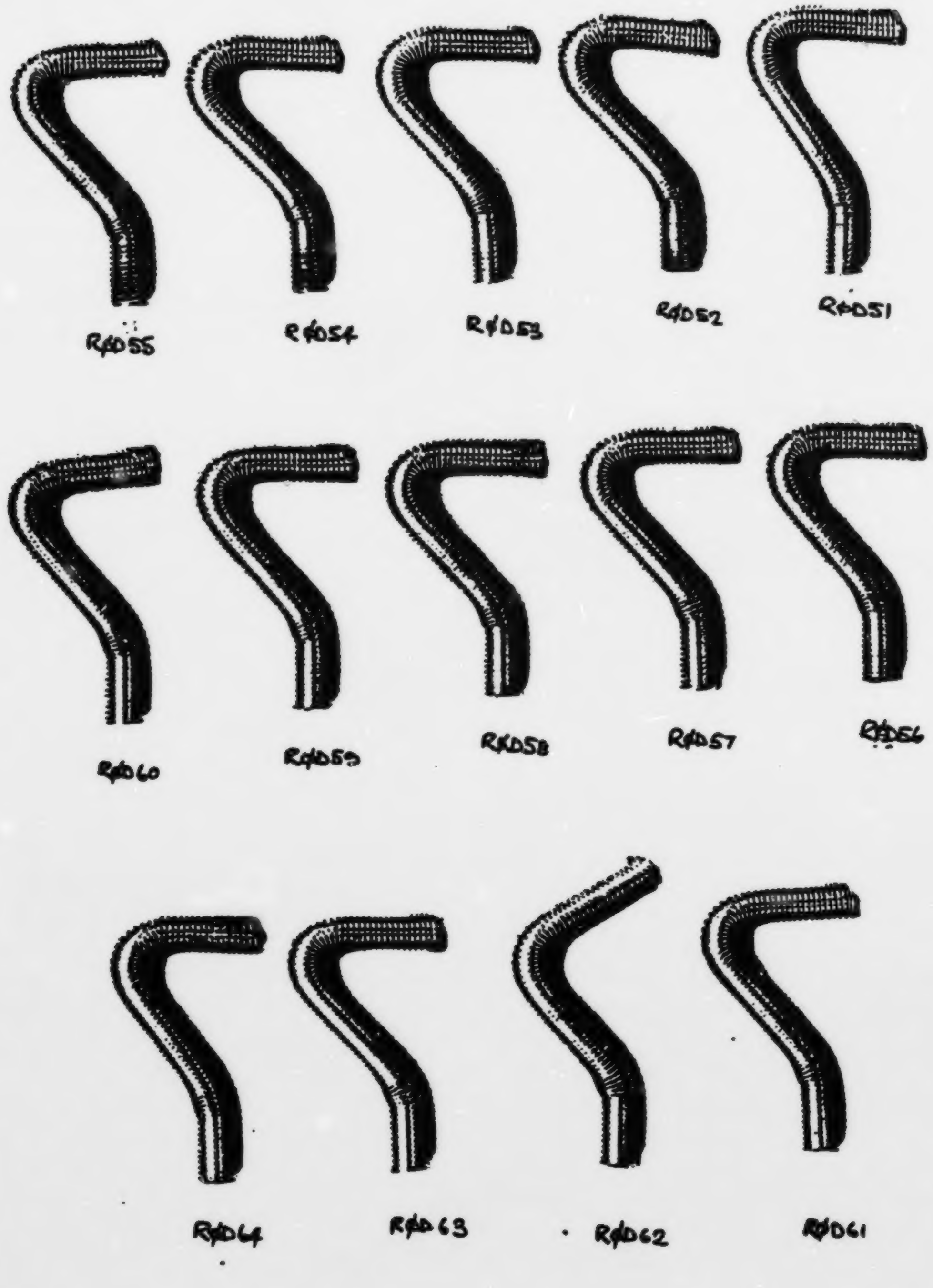

ROD55
ROD54
ROD53
ROD52
ROD51
ROD60
ROD59
ROD58
ROD57
ROD56
ROD64
ROD63
ROD62
ROD61

FIGURE A.2

DEFORMED ROD SPECIMENS

TABLE A.1

SUMMARY OF RESULTS FROM FILTER CUT-OFF FREQUENCY TESTS

ROD SPEC. #	CALC ABSORBED ENRGY (in-lb)		LOADCELL PEAK FORCE (lbs)	FINAL DEFORMATION		CUTOFF FREQUENCY (Hz)
	Accelrmtr	Loadcell		Measured (ins)	Calc (ins)	
ROD64	7153	9436	27205	2.27	2.19	No Filter
ROD53	8055	9492	25392	2.31	2.36	20 000
ROD52	8404	9697	24732	2.27	2.33	10 000
ROD51	8909	9694	24897	2.19	2.27	5 000
ROD54	8287	9551	23083	2.27	2.44	2 000
ROD63	8865	9551	22420	2.39	2.30	2 000
ROD55	2929	9630	23083	2.27	2.41	1 000
ROD56	9582	9561	11706	2.35	2.[illegible]8	500
ROD57	9337	9743	6101	2.35	2.79	200
ROD58	9340	9747	5936	2.39	2.84	200
ROD59	5318	9772	4087	2.31	3.43	100
ROD60	7571	9791	3034	2.15	4.29	50
ROD61	8699	9835	2012	2.27	6.63	20
ROD62	9616	9830	2209	1.60	6.03	20

Rod Length = 5.5 inches
Drop Height = 60 inches
Hammer Weight = 165 lbs
Theoretical Hammer Energy = 9900 in-lbs

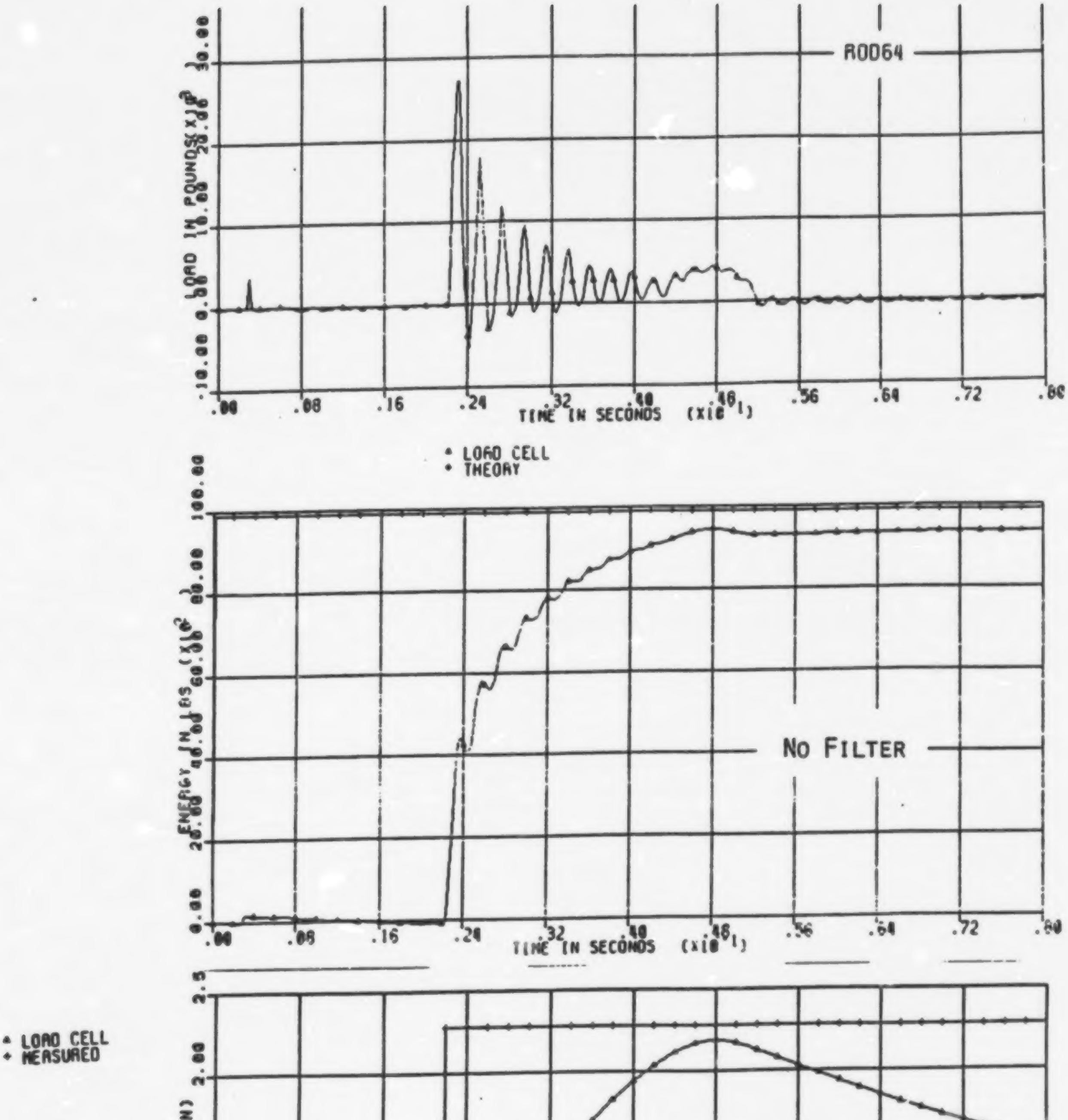

ROD64
LOAD IN POUNDS (X10^3)
-10.00
0.00
10.00
20.00
30.00
.00
.08
.16
.24
.32
.40
.48
.56
.64
.72
.80
TIME IN SECONDS (X10^-1)
LOAD CELL
THEORY
ENERGY IN LBS (X10^2)
0.00
20.00
40.00
60.00
80.00
100.00
No Filter
LOAD CELL
MEASURED
DEFORMATION (IN)
0.00
.50
1.00
1.50
2.00
2.5

FIGURE A.3

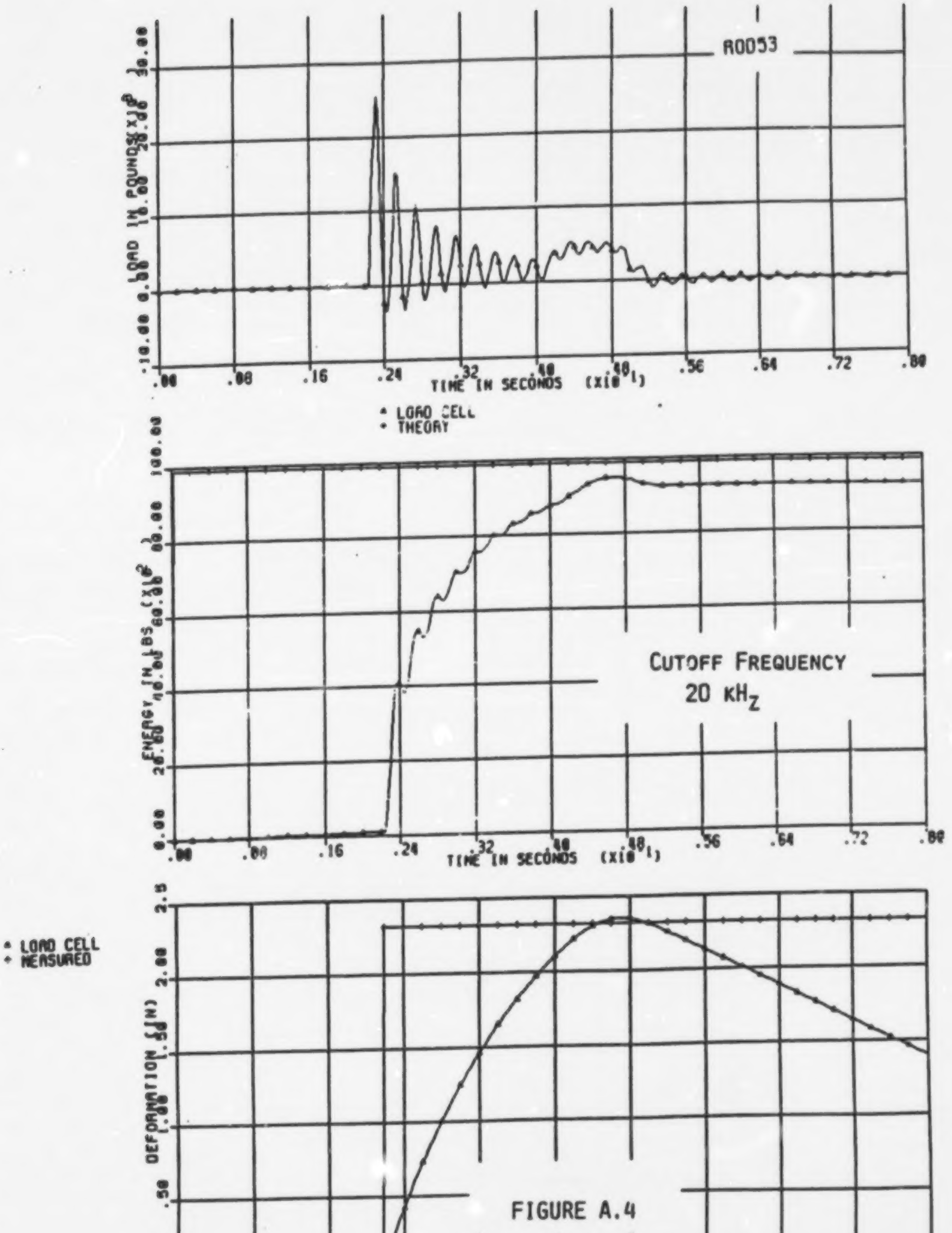
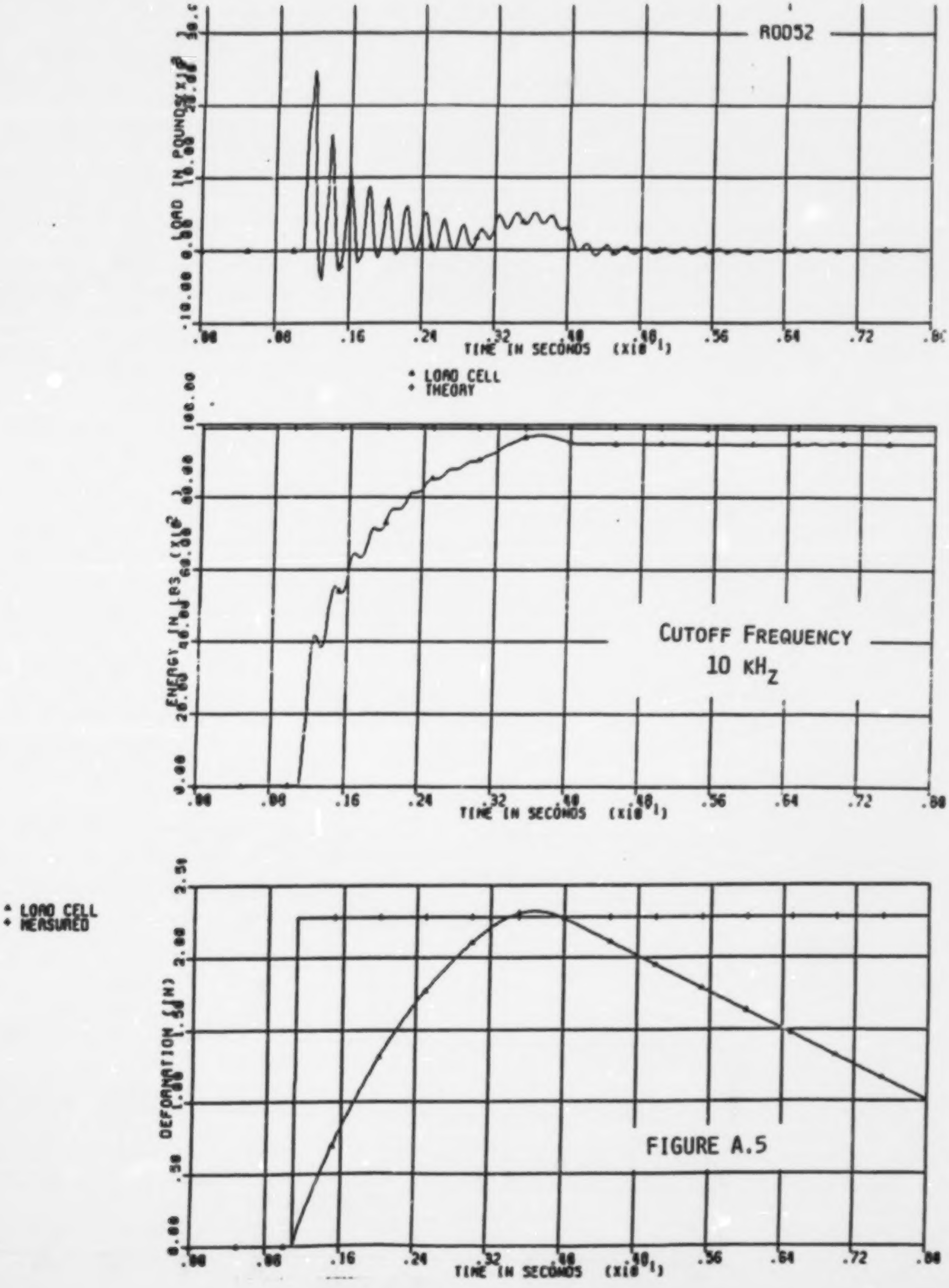

ROD53
LOAD IN POUNDS (x10³)
30.00
20.00
10.00
0.00
-10.00
.00
.08
.16
.24
.32
.40
.48
.56
.64
.72
.80
TIME IN SECONDS (x10⁻¹)
* LOAD CELL
+ THEORY
ENERGY IN LBS (x10²)
100.00
80.00
60.00
40.00
20.00
0.00
CUTOFF FREQUENCY
20 kHz
* LOAD CELL
+ MEASURED
DEFORMATION (IN)
2.50
2.00
1.50
1.00
.50
0.00

FIGURE A.4



CUTOFF FREQUENCY
10 KHZ

FIGURE A.5

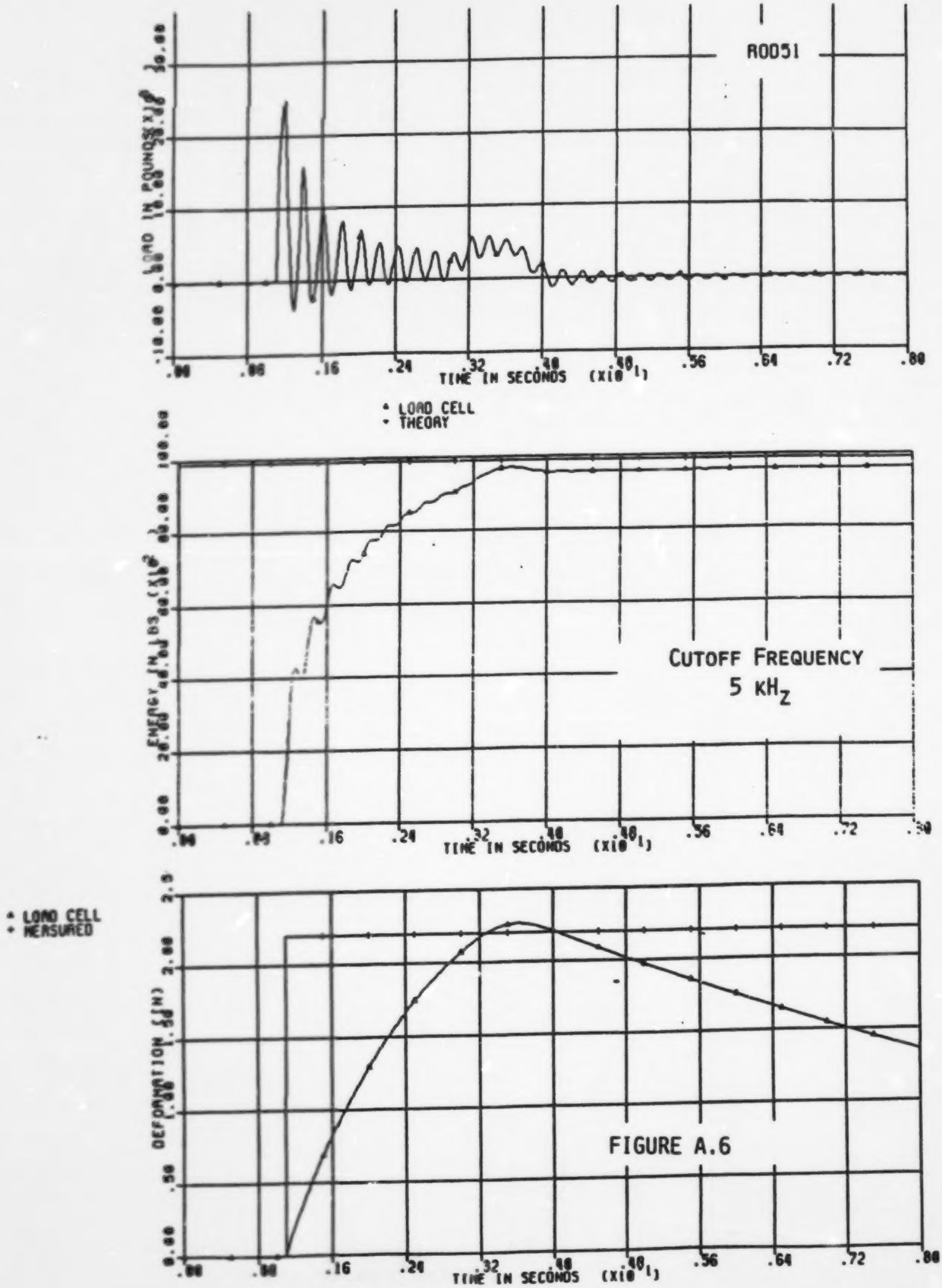

ROD51
LOAD IN POUNDS (X10²)
-10.00
0.00
10.00
20.00
30.00
.00
.08
.16
.24
.32
.40
.48
.56
.64
.72
.80
TIME IN SECONDS (X10⁻¹)
• LOAD CELL
• THEORY
ENERGY (IN-LBS) (X10²)
0.00
20.00
40.00
60.00
80.00
100.00
CUTOFF FREQUENCY
5 KHz
TIME IN SECONDS (X10⁻¹)
• LOAD CELL
• MEASURED
DEFORMATION (IN)
0.00
.50
1.00
1.50
2.00
2.50
TIME IN SECONDS (X10⁻¹)

FIGURE A.6

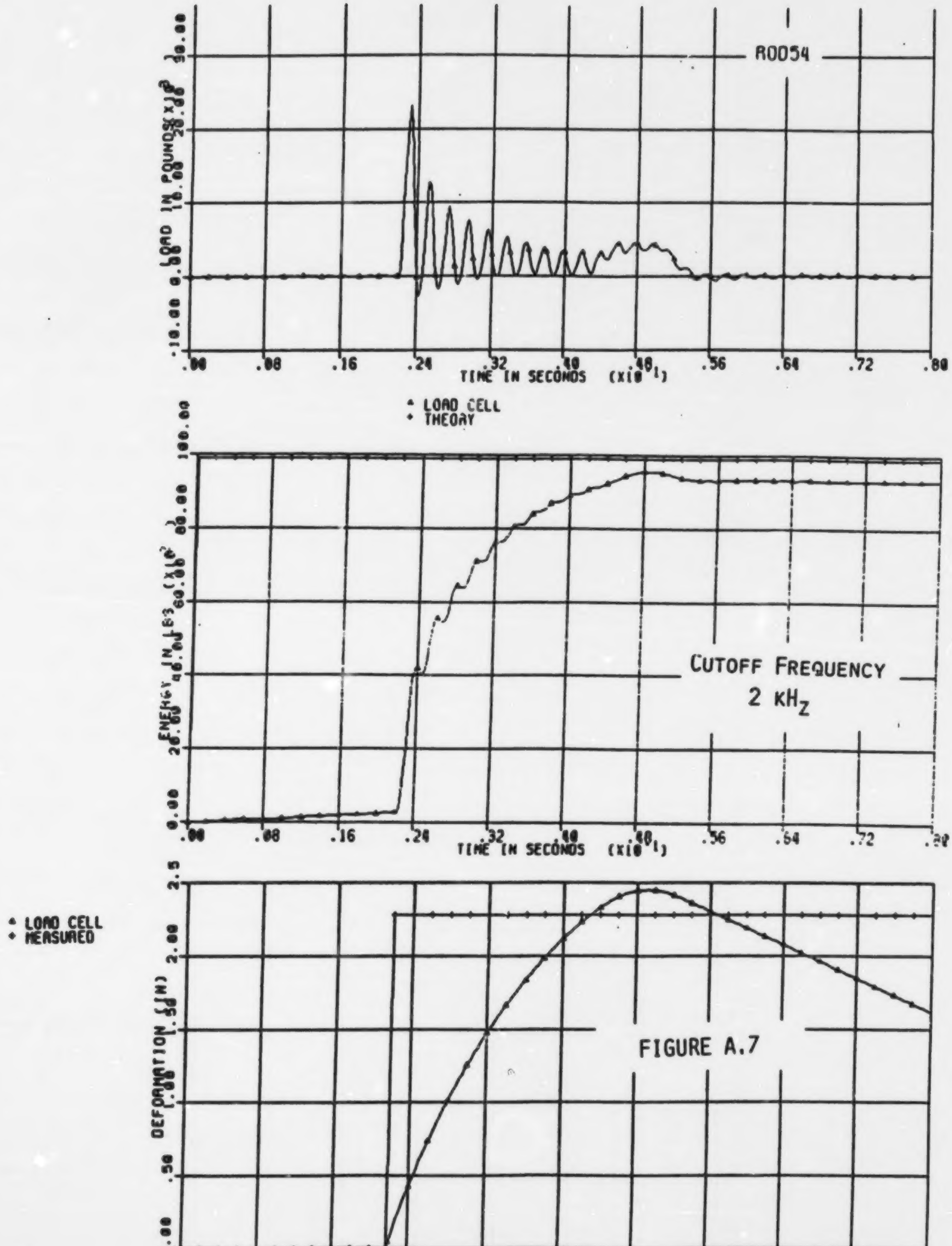

R0054
LOAD IN POUNDS (x10^3)
30.00
20.00
10.00
0.00
-10.00
.00
.08
.16
.24
.32
.40
.48
.56
.64
.72
.80
TIME IN SECONDS (x10^-1)
LOAD CELL
THEORY
ENERGY IN IN-LBS (x10^2)
100.00
80.00
60.00
40.00
20.00
0.00
CUTOFF FREQUENCY
2 kHz
TIME IN SECONDS (x10^-1)
LOAD CELL
MEASURED
DEFORMATION (IN)
2.50
2.00
1.50
1.00
.50
0.00
TIME IN SECONDS (x10^-1)

FIGURE A.7

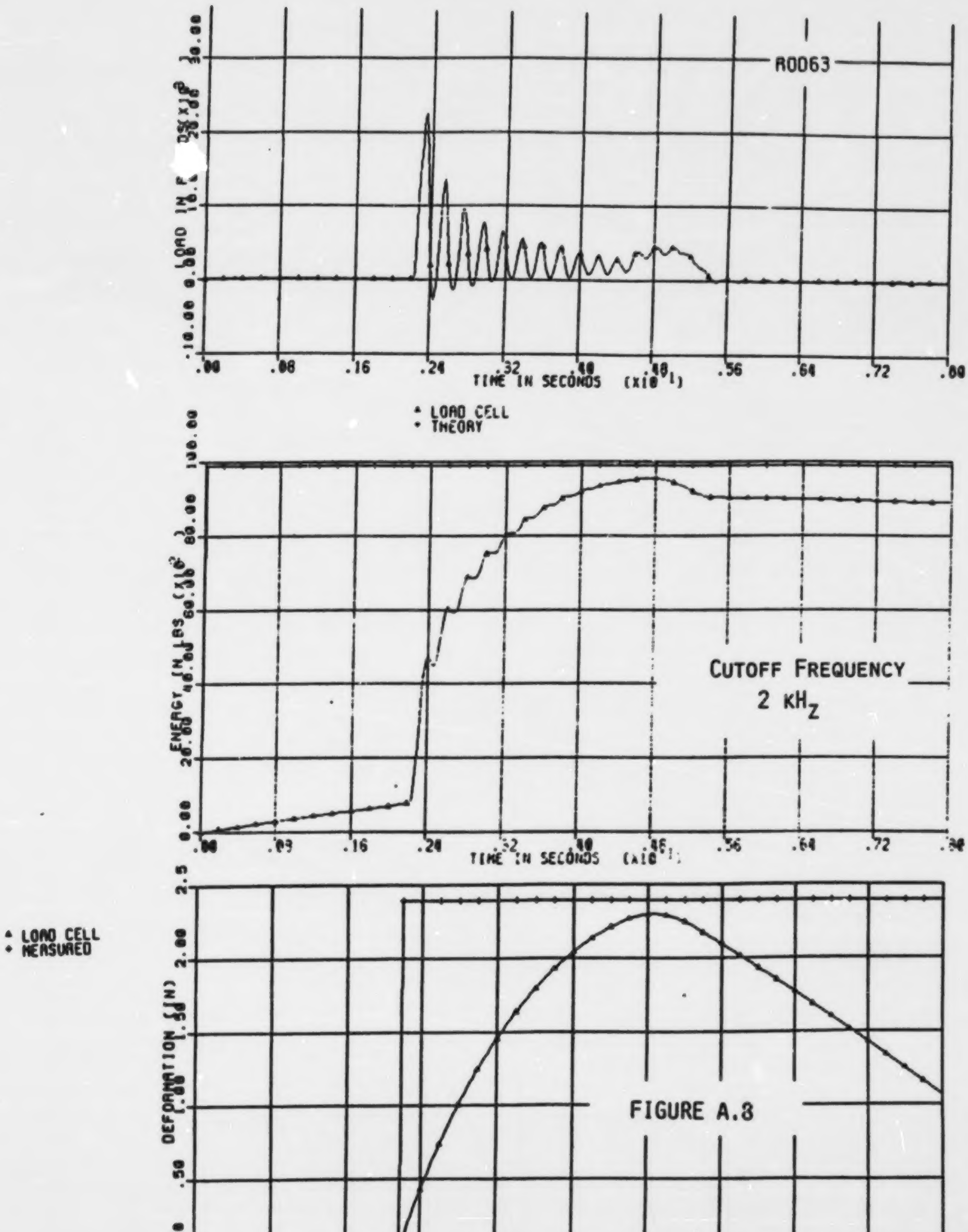
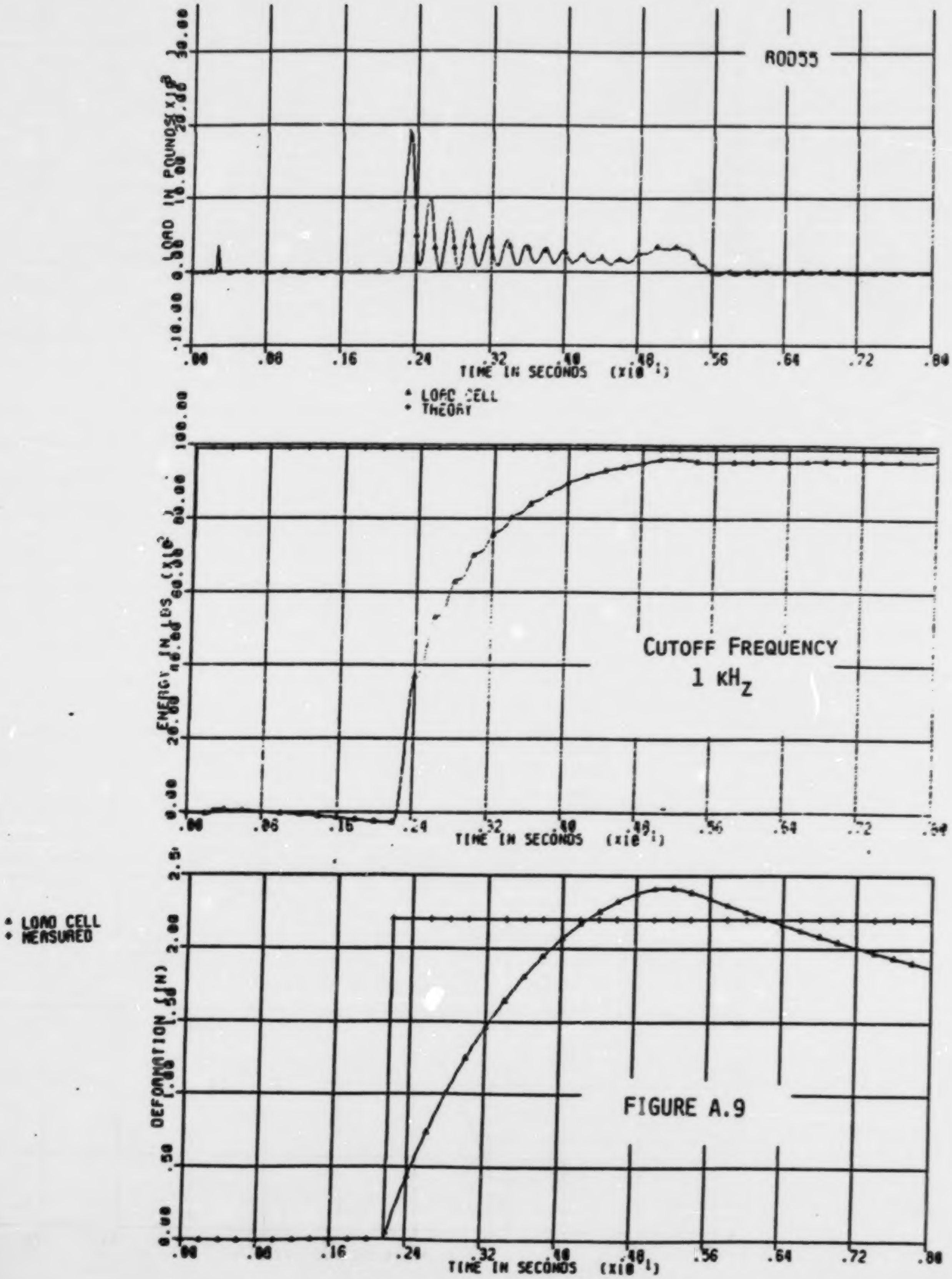

R0D63
LOAD IN LBS (x10^3)
30.00
20.00
10.00
0.00
-10.00
TIME IN SECONDS (x10^-1)
.00
.08
.16
.24
.32
.40
.48
.56
.64
.72
.80
▲ LOAD CELL
◆ THEORY
ENERGY IN LBS (x10^2)
100.00
80.00
60.00
40.00
20.00
0.00
Cutoff Frequency
2 kHz
TIME IN SECONDS (x10^-1)
▲ LOAD CELL
◆ MEASURED
DEFORMATION (IN)
2.5
2.00
1.50
1.00
.50
0.00
TIME IN SECONDS (x10^-1)

FIGURE A.8



ROD55
LOAD IN POUNDS (x10^3)
30.00
20.00
10.00
0.00
-10.00
.00
.08
.16
.24
.32
.40
.48
.56
.64
.72
.80
TIME IN SECONDS (x10^-1)
* LOAD CELL
* THEORY
ENERGY IN LBS (x10^2)
100.00
80.00
60.00
40.00
20.00
0.00
CUTOFF FREQUENCY
1 kH_Z
DEFORMATION (IN)
2.50
2.00
1.50
1.00
.50
0.00
* LOAD CELL
* MEASURED

FIGURE A.9

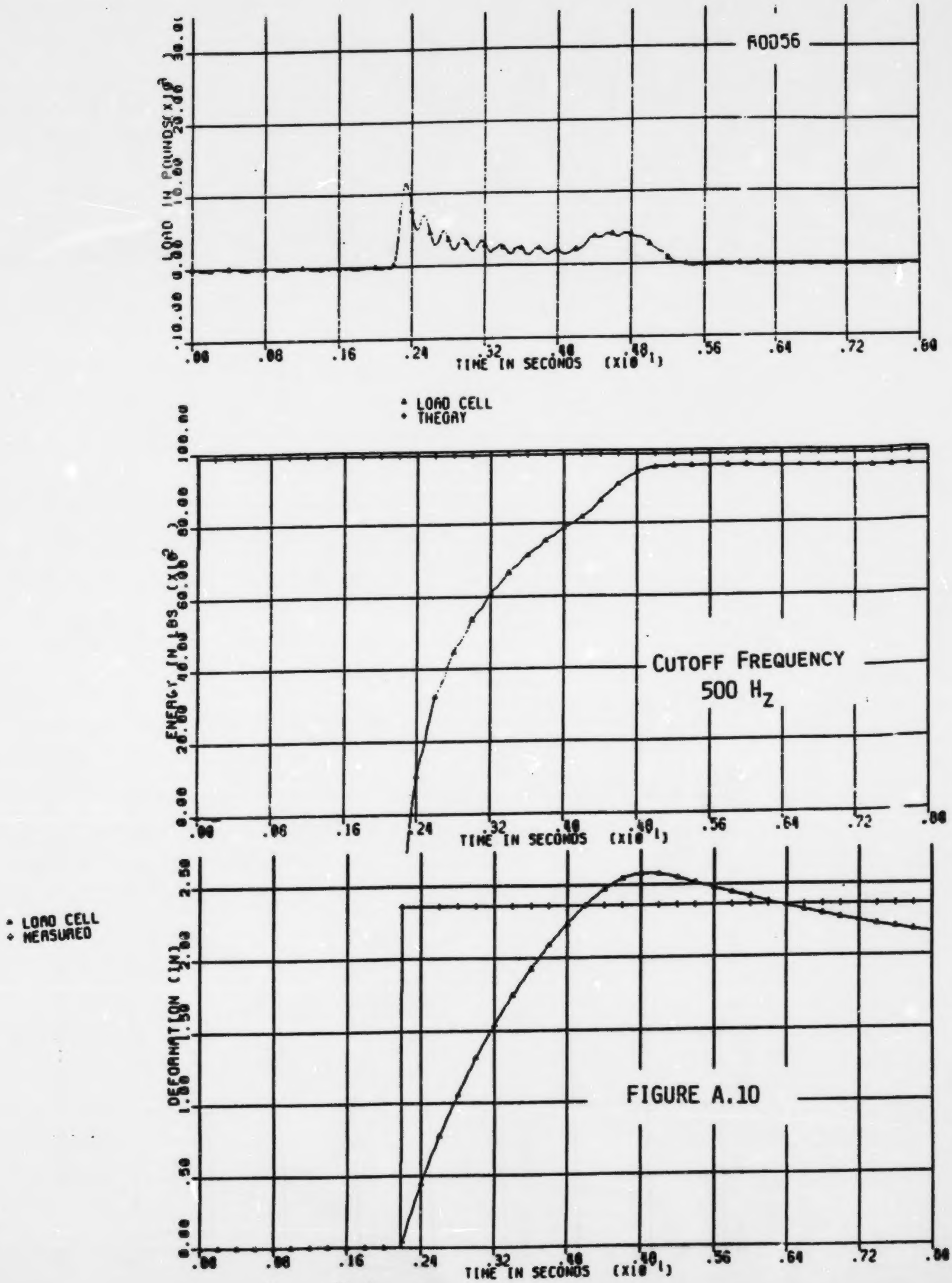

ROD56
LOAD IN POUNDS (x10^2)
-10.00
0.00
10.00
20.00
30.00
.00
.08
.16
.24
.32
.40
.48
.56
.64
.72
.80
TIME IN SECONDS (x10^-1)
LOAD CELL
THEORY
ENERGY (IN LBS (x10^2))
0.00
20.00
40.00
60.00
80.00
100.00
CUTOFF FREQUENCY
500 H_Z
LOAD CELL
MEASURED
DEFORMATION (IN)
0.00
.50
1.00
1.50
2.00
2.50

FIGURE A.10

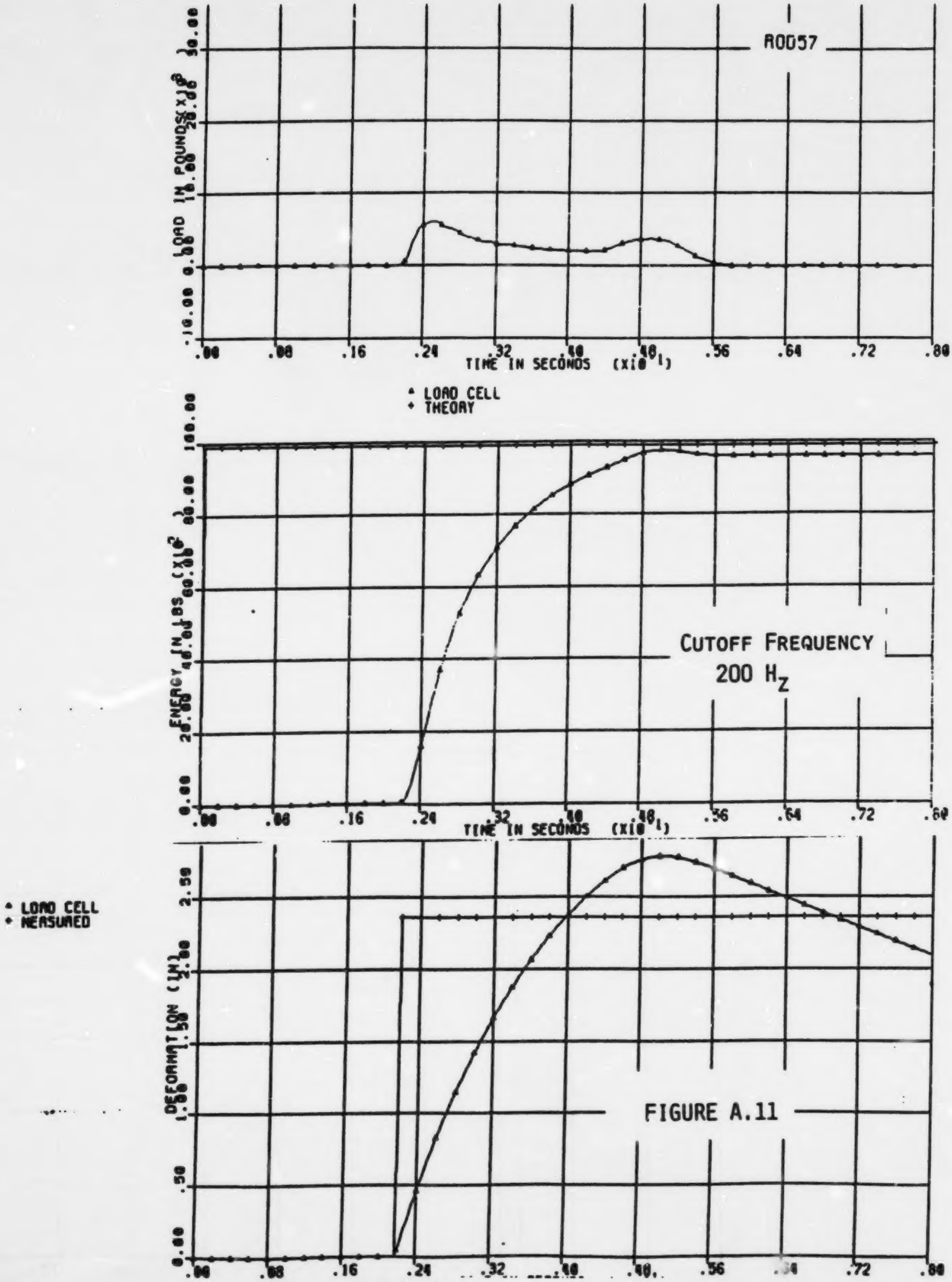
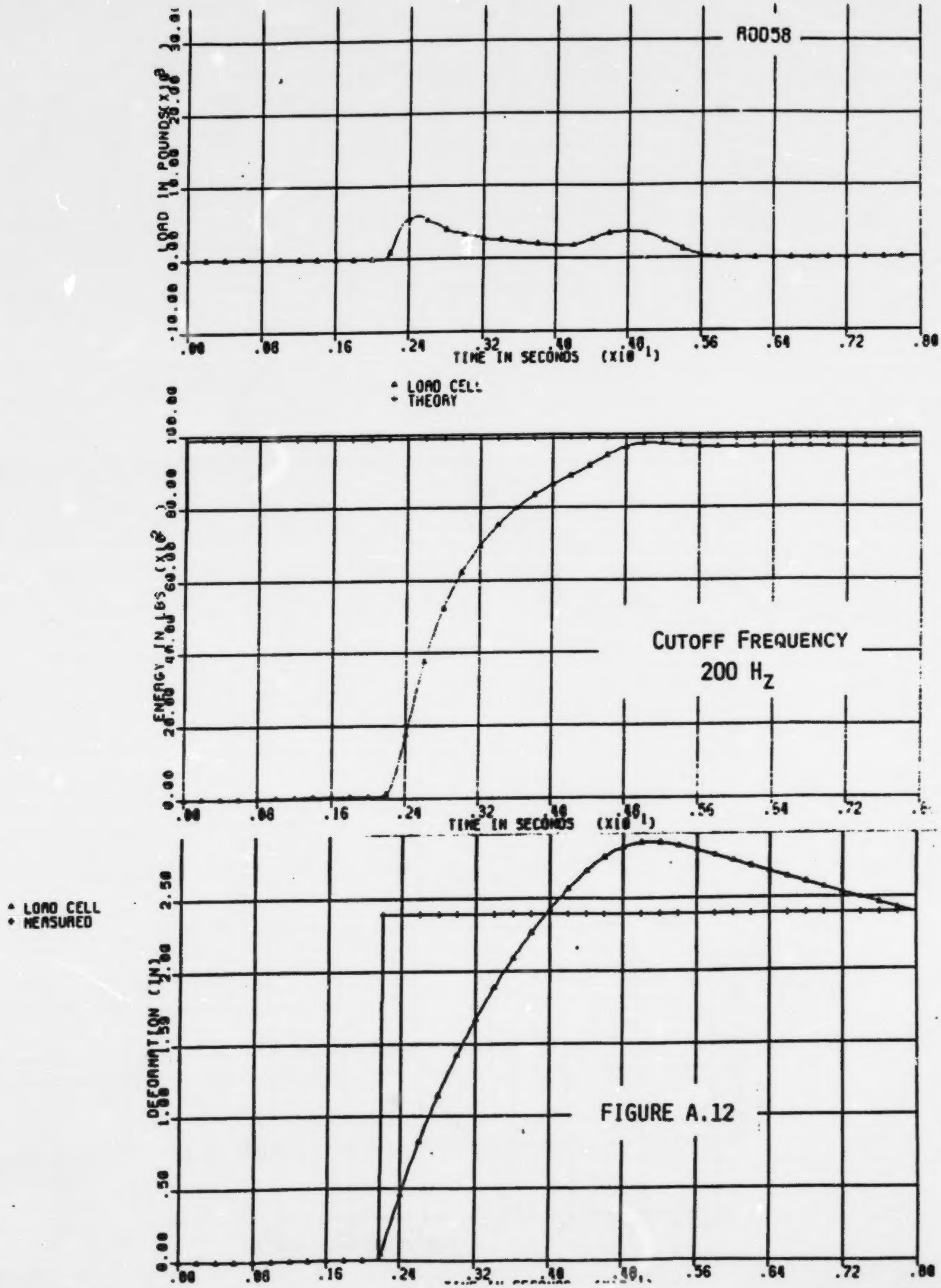

R0057
LOAD IN POUNDS(X10³)
-10.00
0.00
10.00
20.00
30.00
TIME IN SECONDS (X10⁻¹)
.00
.08
.16
.24
.32
.40
.48
.56
.64
.72
.80
LOAD CELL
THEORY
ENERGY (IN LBS (X10²)
0.00
20.00
40.00
60.00
80.00
100.00
CUTOFF FREQUENCY
200 Hz
LOAD CELL
MEASURED
DEFORMATION (IN)
0.00
.50
1.00
1.50
2.00
2.50

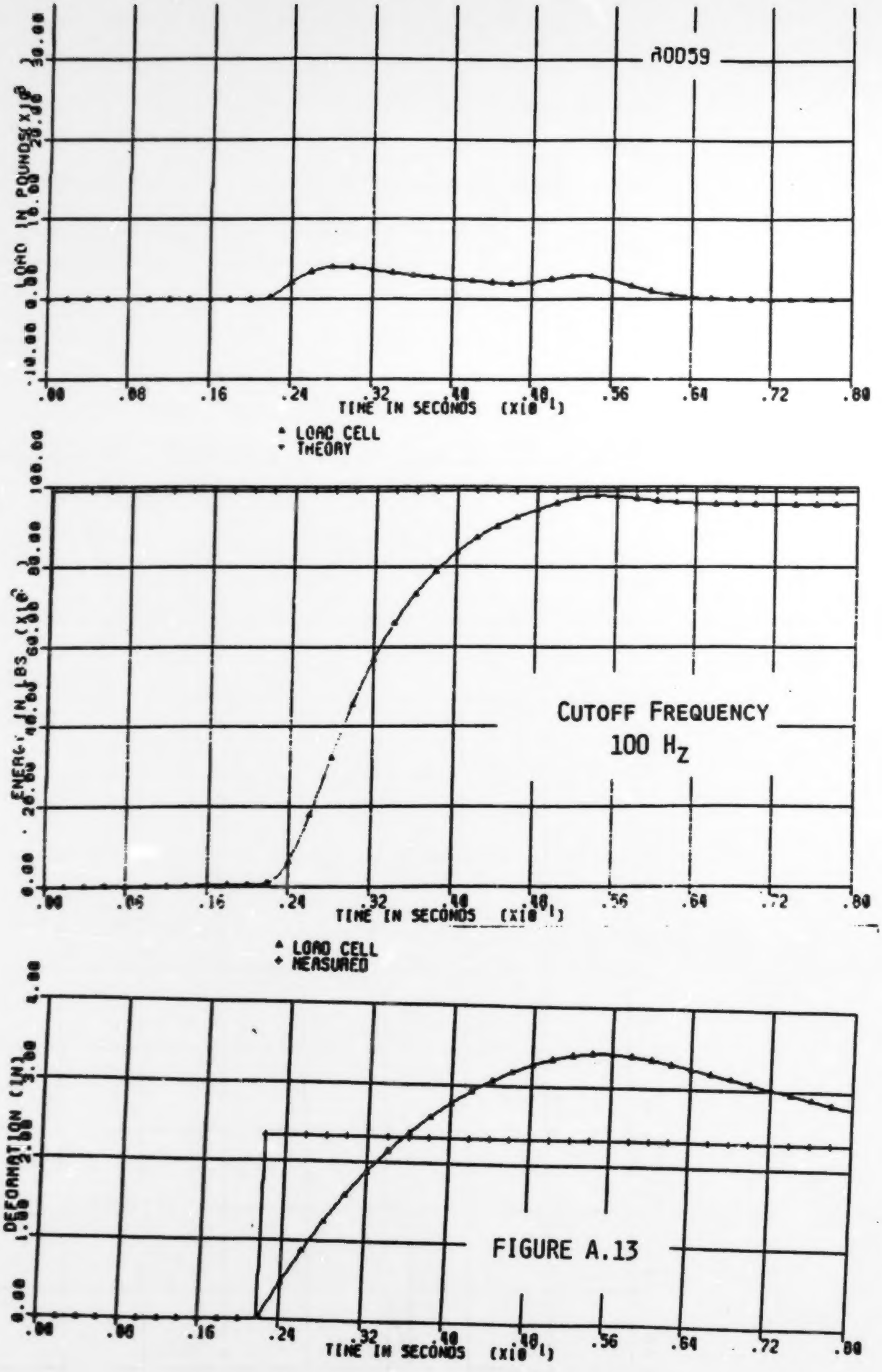
FIGURE A.11



R0058

CUTOFF FREQUENCY
200 H_Z

FIGURE A.12



CUTOFF FREQUENCY
100 H_Z

FIGURE A.13

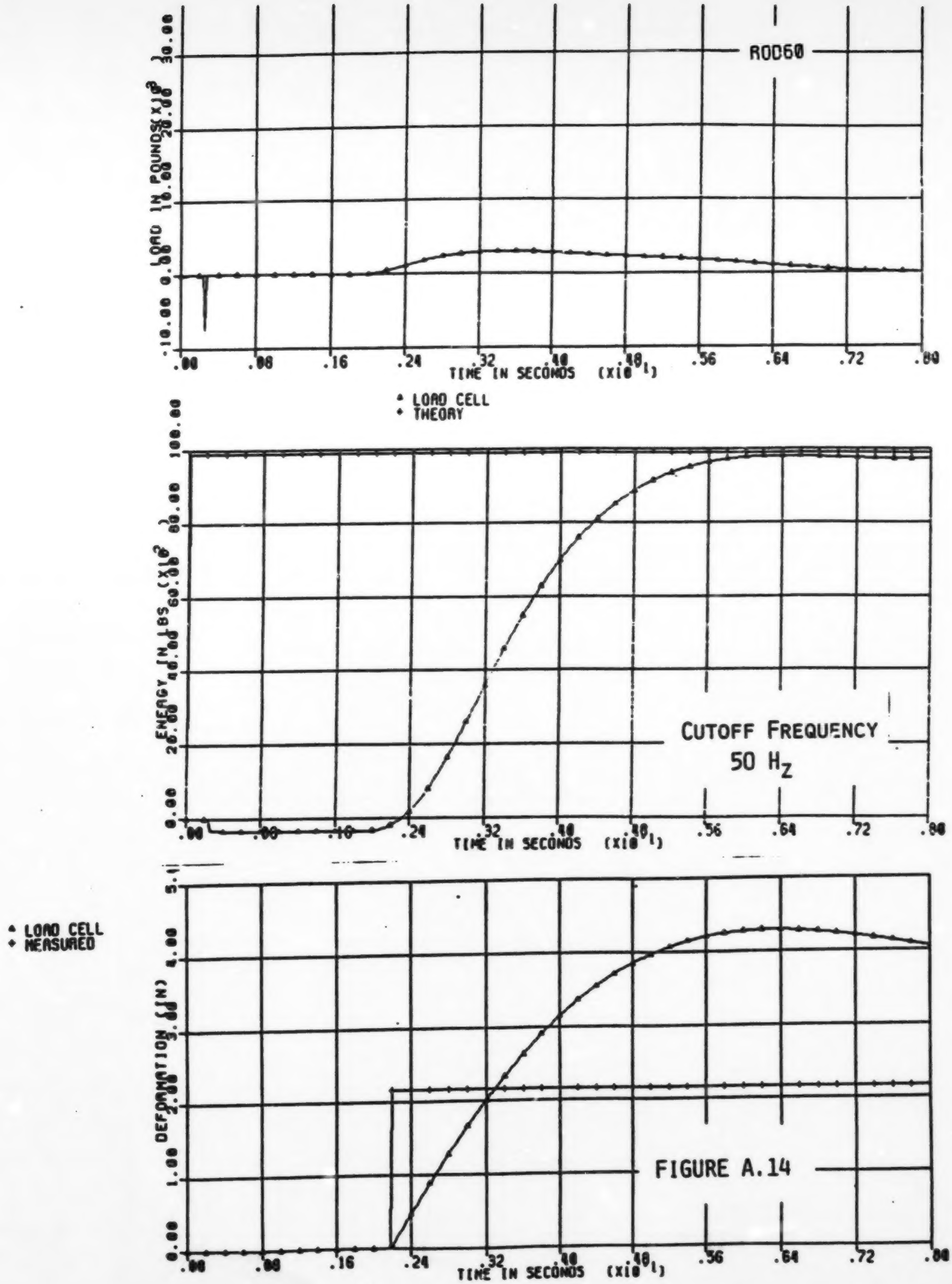

ROD60
LOAD IN POUNDS (X10³)
-10.00
0.00
10.00
20.00
30.00
.00
.08
.16
.24
.32
.40
.48
.56
.64
.72
.80
TIME IN SECONDS (X10⁻¹)
LOAD CELL
THEORY
ENERGY IN LBS (X10³)
0.00
20.00
40.00
60.00
80.00
100.00
CUTOFF FREQUENCY
50 Hz
LOAD CELL
MEASURED
DEFORMATION (IN)
0.00
1.00
2.00
3.00
4.00
5.1

FIGURE A.14

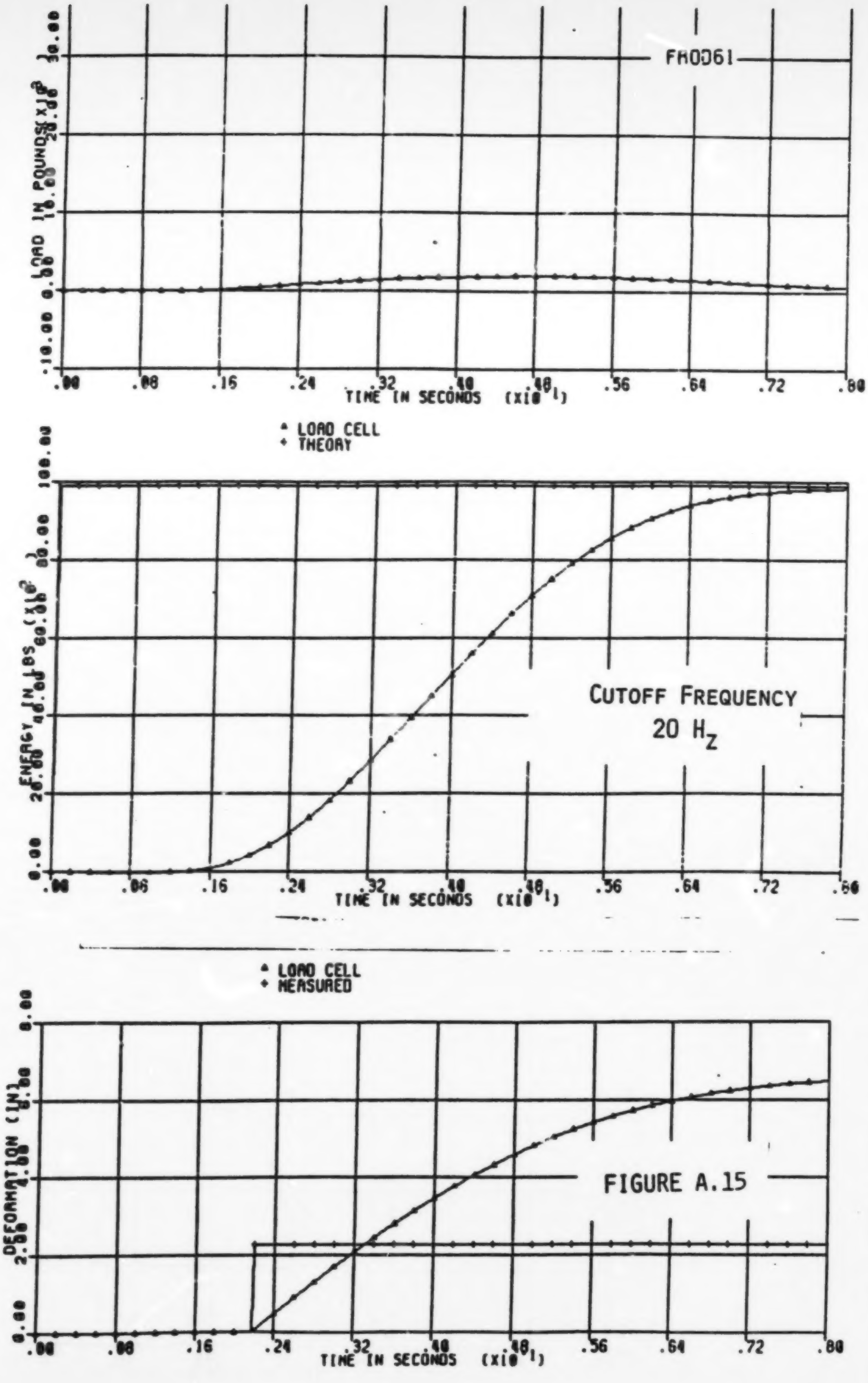

FRO061
LOAD IN POUNDS (X10³)
30.00
20.00
10.00
0.00
-10.00
.00
.08
.16
.24
.32
.40
.48
.56
.64
.72
.80
TIME IN SECONDS (X10⁻¹)
LOAD CELL
THEORY
ENERGY IN LBS (X10²)
100.00
80.00
60.00
40.00
20.00
0.00
CUTOFF FREQUENCY
20 HZ
LOAD CELL
MEASURED
DEFORMATION (IN)
8.00
6.00
4.00
2.00
0.00

FIGURE A.15

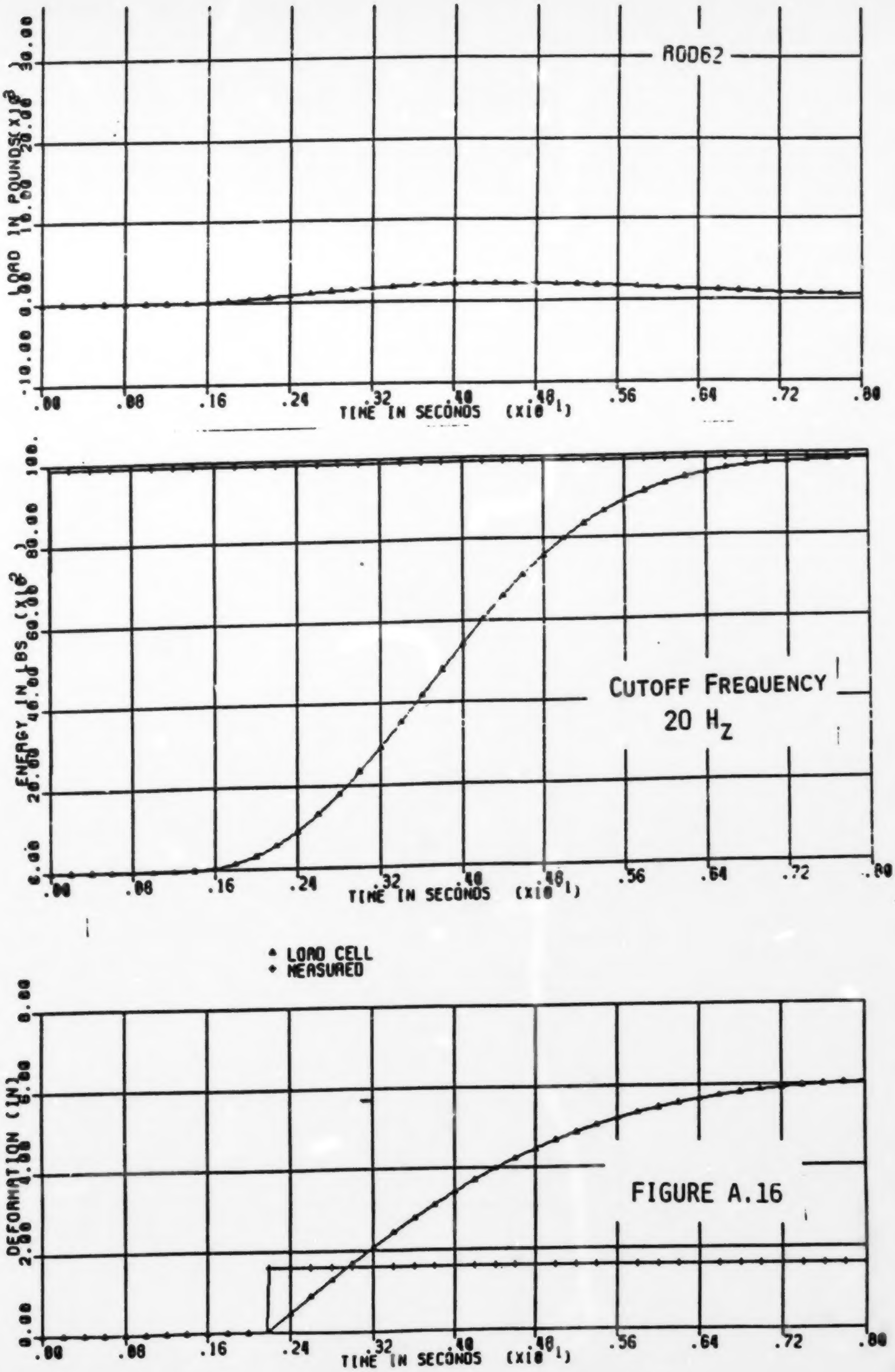

R0062
LOAD IN POUNDS (x10³)
-10.00
0.00
10.00
20.00
30.00
TIME IN SECONDS (x10⁻¹)
.00
.08
.16
.24
.32
.40
.48
.56
.64
.72
.80
ENERGY IN LBS (x10²)
0.00
20.00
40.00
60.00
80.00
100.
CUTOFF FREQUENCY
20 Hz
TIME IN SECONDS (x10⁻¹)
• LOAD CELL
• MEASURED
DEFORMATION (IN)
0.00
2.00
4.00
6.00
8.00
TIME IN SECONDS (x10⁻¹)

FIGURE A.16

FIGURE A.17

VARIATION OF MEASURED PEAK FORCE
WITH FILTER CUTOFF FREQUENCY

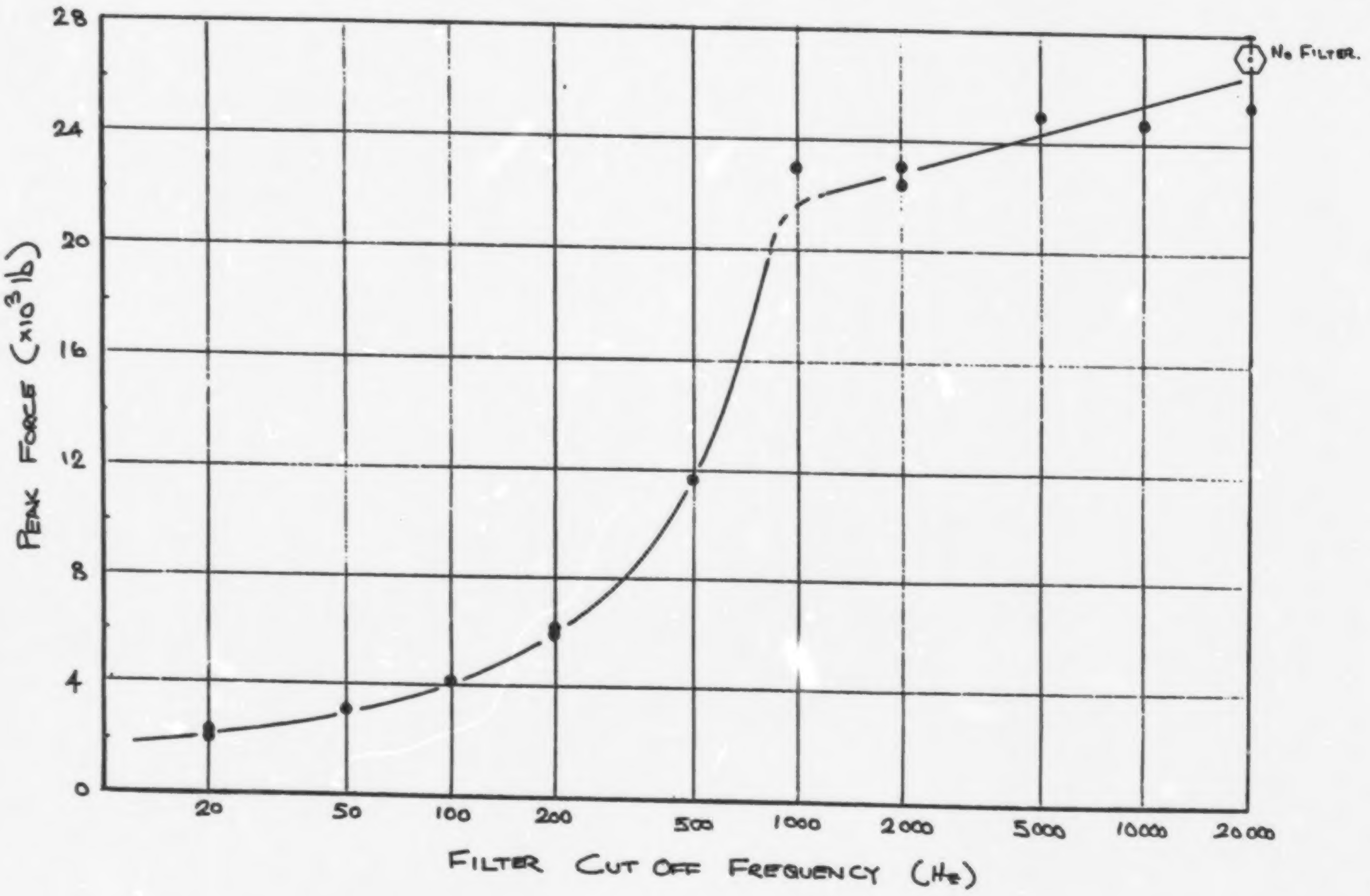


FIGURE A.18

VARIATION OF CALCULATED ABSORBED ENERGY
WITH FILTER CUTOFF FREQUENCY